AEA

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Annual Report for 2010

Report to Defra and the Devolved Administrations

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Executive summary

This report provides a summary of the site management and data produced in 2010 by two UK air quality monitoring networks:

1. Automatic hydrocarbon network
2. Non-automatic hydrocarbon network

These networks measure benzene, 1,3-butadiene and ozone precursor substances at sites across the UK.

The report includes an introduction to the networks, the history of monitoring and the reasons for monitoring these pollutants. Section 2 provides detailed information on the sites currently operating and recent changes to the sites. In section 3 and Appendix 1 summary data is presented and analysed, including a review of the long-term trends and a description of issues that have affected data capture or data quality. The report also includes a summary of the quality assurance and quality control procedures in sections 2 and 4 and an update on future changes in section 5.

The mean data capture for benzene measured by the non-automatic hydrocarbon network in 2010 was 92%. The annual mean across all measurement sites in the UK was 0.92 $\mu g\ m^{-3}$. The mean data capture for benzene measured by the automatic hydrocarbon network in 2010 was 77%. The annual mean across all measurement sites in the UK was 0.73 $\mu g\ m^{-3}$. The overall data capture for benzene reported to the European Commission will be 90%.

In 2010 none of the monitoring sites in the UK exceeded the Limit Value for benzene set out in Directive 2008/50/EC. All sites measured an annual mean that was less than the Lower Assessment Threshold.

This report is prepared by AEA with contribution from the National Physical Laboratory.

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Appendices

1 Introduction

This report provides a summary of the site management and data produced in 2010 by two UK air quality monitoring networks:

1. Automatic hydrocarbon network
2. Non-automatic hydrocarbon network

The automatic hydrocarbon network was managed by AEA throughout 2010. There was a change in contractor for the non-automatic hydrocarbon network at the start of July 2010. From 1st January to 30th June, the network was managed and data ratified by the National Physical Laboratory (NPL). From 1st July to 31st December, the network was managed and data ratified by AEA.

All hydrocarbon network instruments are collocated at AURN (Automatic Urban and Rural Network) sites. These have all been assessed with respect to the macroscale and microscale siting criteria in the Directive. The initial assessment indicates that all of the hydrocarbon network sites comply with the Directive, with the exception of Bury Roadside and Bristol Old Market. Both sites are believed to be too close to major road junctions to be representative of the local area, and additionally, the Bury Roadside site is too far from the carriageway to be a 'traffic' site. At the time of writing this report, a full assessment of the sites against the criteria in Directive 2008/50/EC is underway and the results will be available later in 2011.

The number of and location of sites in these networks are based upon a preliminary assessment against the sampling requirements in Annex V of the Directive, undertaken in 2006.

The information and data presented in this report are correct at the time of publication, however, it is possible that data may be rescaled or deleted from the dataset if future audits and calibrations identify a need to change the data. Latest data can always be accessed at http://uk-air.defra.gov.uk/.

1.1 Pollutant Sources and Impacts

According to the UK Air Quality Strategy[1] benzene has a variety of sources, but primarily arises from domestic and industrial combustion and road transport. It is a recognised human carcinogen that attacks the genetic material and, as such, no absolutely safe level can be specified in ambient air. Studies in workers exposed to high levels have shown an excessive risk of leukaemia.

1,3-butadiene is emitted from combustion of petrol. Motor vehicles and other machinery are the dominant sources, but it is also emitted from some processes, such as production of synthetic rubber for tyres. 1,3-butadiene is also a recognised genotoxic human carcinogen, as such, no absolutely safe level can be specified in ambient air. The health effect of most concern is the induction of cancer of the lymphoid system and blood–forming tissues, lymphoma and leukaemia.

[1] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1), Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, July 2007

1.2 Network background and methods

The Non-Automatic and Automatic Hydrocarbon Networks exist within the framework of Defra's Atmosphere and Local Environment Programme. This aims to determine the magnitude of sources and effects of air pollutants on human health and the environment, and to comply with national and EU legislation.

1.2.1 Non-Automatic Hydrocarbon Network

The Non-Automatic Hydrocarbon Network started operation in 2001, measuring benzene and 1,3-butadiene. It currently produces measurements as fortnightly averages at 36 sites. The network was reviewed in 2007 and 1,3-butadiene monitoring was discontinued due to the very low concentrations measured.

The benzene monitoring method involves pumping ambient air at a rate nominally 10 ml/min alternately through two tubes containing a sorbent (Carbopack X). The tubes are then sent to the laboratory for subsequent analysis of their benzene content. The exposure period and flow rate is important such that enough benzene is captured onto the sorbent to enable fully quantifiable analysis, but not too much that there is breakthrough of the sample. This dual sample tube controlled flow pump unit uses a method described in EN 14662:2005, 'Ambient air quality – Standard method for measurement of benzene concentrations' by Martin et al, and validated by Quincey et al.

1.2.2 Automatic Hydrocarbon Network

Automatic gas chromatography is used to measure hourly hydrocarbon concentrations. During 2010, hydrocarbons at all sites except Glasgow were measured using automatic Perkin Elmer gas chromatographs. A known volume of air is dried and drawn through the cold trap, which contains adsorbent material. The cold trap is held at about -30^{o}C to ensure that all the ozone precursor target analytes are retained. The analyser is calibrated using an on-site multi-component gas mixture. Following a 40 minute period of sampling, components are desorbed from the cold trap and are transferred to the capillary column where they are separated using gas-chromatography.

At Glasgow measurements of 1,3-butadiene, benzene, toluene, ethylbenzene and xylenes were made using an Environnement VOC71M analyser. This sampled ambient air continuously using two traps. One desorption tube samples while the other is desorbed and analysed. The hydrocarbons were measured using gas chromatography coupled with a photo-ionisation detector.

Automatic hourly measurements of speciated hydrocarbons, made using advanced automatic gas chromatography, started in the UK in 1991. By 1995, monitoring had expanded considerably with the formation of a 13-site dedicated network measuring 26 species continuously at urban, industrial and rural locations. Over the following years, the number of sites was reduced. In 2010 there were five sites, measuring some or all of the following species by automatic gas chromatographs:

Table 1 Species measured by the Automatic chromatographs.

Pollutant	Pollutant	Pollutant
1,2,3-trimethylbenzene	ethane	n-heptane
1,2,4-trimethylbenzene	ethene	n-hexane
1,3,5-trimethylbenzene	ethylbenzene	n-octane
1,3-Butadiene	ethyne (acetylene)	n-pentane
1-butene	iso-butane (I-butane)	o-xylene
1-pentene	iso-octane	propane
2-methylpentane	iso-pentane	propene
3-methylpentane	isoprene	toluene
benzene	m+p-xylene	trans-2-butene
cis-2-butene	methylpentane	trans-2-pentene
cis-2-pentene	n-butane	

1.3 Regulatory background

1.3.1 UK Air Quality Objectives

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, (July 2007) sets out the UK Air Quality Objectives for benzene and 1,3-butadiene:

Table 2 UK Air Quality Objectives.

Pollutant	Applicable to	Concentration	Measured As	To be achieved by
Benzene	All authorities	16.25 µg m^{-3}	Running annual mean	31 December 2003
	England and Wales Only	5.00 µg m^{-3}	Annual mean	31 December 2010
	Scotland and N. Ireland	3.25 µg m^{-3}	Running annual mean	31 December 2010
1,3-Butadiene	All authorities	2.25 µg m^{-3}	Running annual mean	31 December 2003

1.3.2 European Limit Value

Hydrocarbons are also governed by Directive 2008/E50/EC of the European Parliament and of the Council of 21 May 2008, on ambient air quality and cleaner air for Europe (the Directive). The Directive sets a limit value for annual mean benzene concentrations across the UK.

Table 3 European Limit Value and Assessment Thresholds

Threshold	Concentration	Measured as
Limit Value	5µg m^{-3}	Annual mean
Upper assessment threshold	3.5µg m^{-3}	Annual mean
Lower assessment threshold	2µg m^{-3}	Annual mean

The limit value for the protection of human health for benzene is 5 µg/m^3 as a calendar year mean, to be achieved by 1st January 2010. The determination of requirements for assessment of concentrations of benzene in ambient air is between 3.5 µg/m^3 (70% of limit value) and 2 µg/m^3 (40% of limit value) as upper and lower assessment threshold respectively.

The Data Quality Objective for the measurement uncertainty is ±25% with a minimum data capture of 90%. The minimum time coverage is 35% (distributed over the year) for urban background and traffic sites and 90% for industrial sites.

Annex X of the Directive lists 31 other Volatile Organic Compounds (VOCs) which are ozone precursors and which are recommended to be measured in urban or suburban areas to support the understanding of ozone formation. With the exception of formaldehyde and total non-methane hydrocarbons, these VOCs are all measured by the automatic hydrocarbon network and are listed in section 1. Neither data quality objectives nor limit values are given for measurement of these species, however, Defra have specified that all other VOC compounds have a minimum data capture target of 50%.

2 Site Management

2.1 Network sites during 2010

2.1.1 Non-Automatic Hydrocarbon Network

The sites in the Non-Automatic Hydrocarbon Network are shown in Figure 1. Table 4 lists the sites and the Local Site Operators.

Figure 1 Map of Non-Automatic Hydrocarbon Network sites in 2010

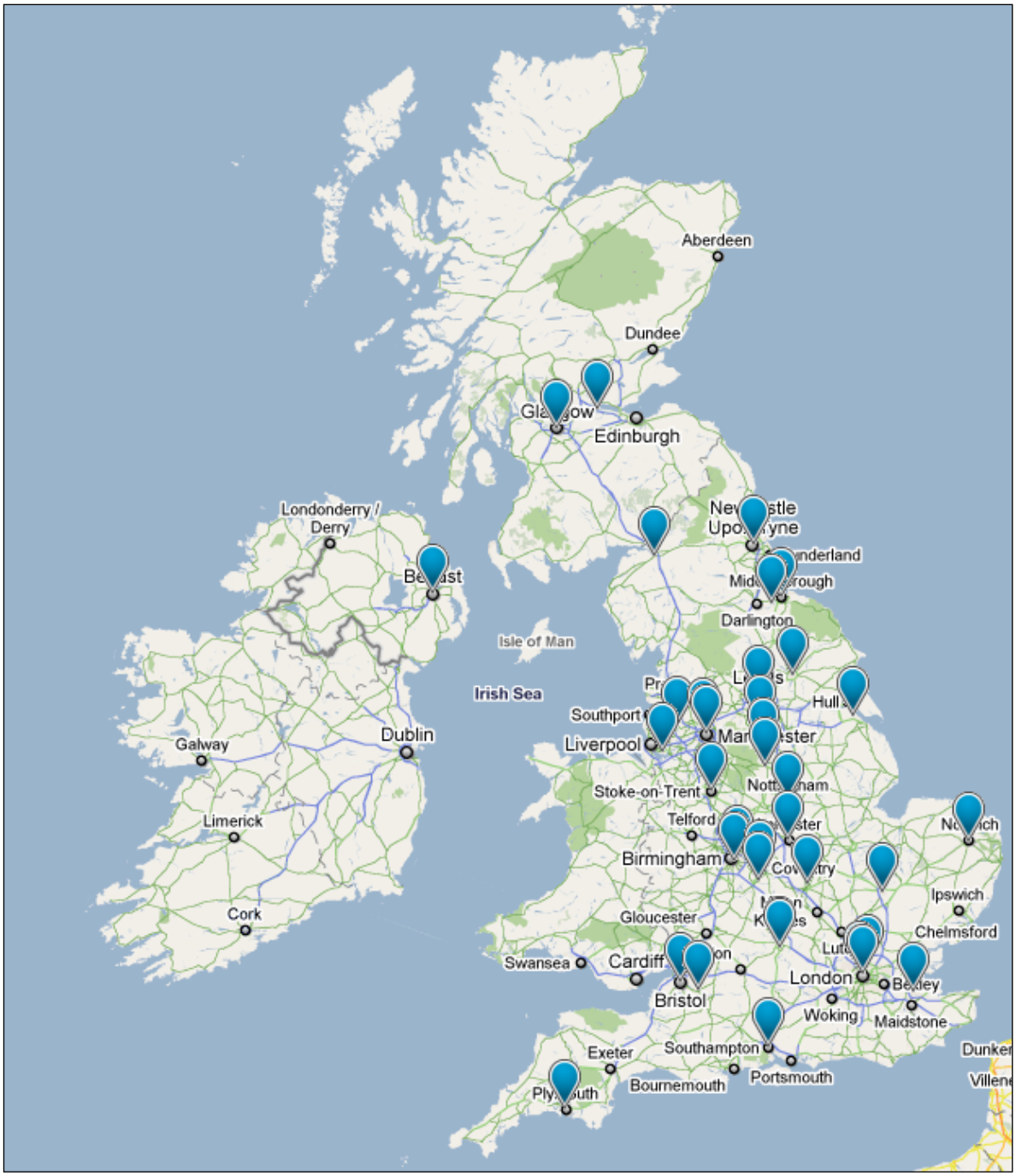


Table 4 Non-Automatic Hydrocarbon Network sites in 2010.

Site	Classification	Zone	Grid Ref Easting / Northing	Local Site Operator
Barnsley Gawber	Urban Background	Yorkshire & Humberside	432529, 407472	Barnsley Council
Bath Roadside	Urban Traffic	South West	375882, 166096	Bath & North Somerset Council
Belfast Centre	Urban Background	Belfast Urban Area	333900, 374400	Belfast City Council
Birmingham Tyburn	Urban Background	West Midlands Urban Area	411561, 290431	Birmingham City Council
Birmingham Tyburn Roadside	Urban Traffic	West Midlands Urban Area	411556, 290456	AECOM
Bimringham Roadside 2	Urban Traffic	West Midlands Urban Area	408824, 284570	Birmingham City Council
Bristol Old Market	Urban Traffic	Bristol Urban Area	359570, 173173	Bristol City Council
Bury Roadside	Urban Traffic	Greater Manchester Urban Area	380922, 404772	Bury Metropolitan Council
Cambridge Roadside	Urban Traffic	Eastern	545248, 258155	Cambridge Council
Camden Kerbside	Urban Traffic	Greater London Urban Area	526640, 184433	KCL / AEA
Carlisle Caldewgate	Urban Traffic	North West & Merseyside	339442, 555956	Carlisle Council
Chatham Centre Roadside	Urban Traffic	South East	577435, 166993	Medway Council
Chesterfield	Urban Background	East Midlands	436351, 370682	Chesterfield Council
Coventry Memorial Park	Urban Background	Coventry/Bedworth	432801, 277340	Coventry City Council
Glasgow Kerbside	Urban Traffic	Glasgow Urban Area	258708, 665200	AEA
Grangemouth	Urban Industrial	Central Scotland	293837, 681035	Falkirk Council
Haringey Roadside	Urban Traffic	Greater London Urban Area	533885, 190669	KCL
Leamington Spa	Urban Background	West Midlands	431932, 265743	Warwick District Council
Leeds Centre	Urban Background	West Yorkshire Urban Area	429976, 434268	Leeds City Council
Leicester Centre	Urban Background	Leicester Urban Area	458767, 304083	Leicester City Council
Liverpool Speke	Urban Background	Liverpool Urban Area	343860, 383598	Fabermaunsell/AECOM
London Bloomsbury	Urban Background	Greater London Urban Area	530107, 182041	Bureau Veritas / AEA
Manchester Picadilly	Urban Background	Greater Manchester Urban Area	384310, 398325	Manchester City Council
Middlesbrough	Urban Background	Teesside Urban Area	450480, 519632	Middlesbrough BC
Newcastle Centre	Urban Background	Tyneside	425016, 564940	Newcastle City Council
Northampton	Urban Background	East Midlands	476111, 264524	Northampton BC
Norwich Lakenfields	Urban Background	Eastern	623637, 306940	Mark Leach
Nottingham Centre	Urban Background	Nottingham Urban Area	457420, 340050	Nottingham City Council
Oxford Centre	Urban Traffic	South East	451366, 206152	Oxford City Council
Oxford St Ebbes	Urban Background	South East	451225, 206009	Oxford City Council
Plymouth Centre	Urban Background	South West	247742, 54610	Plymouth City Council
Sheffield Centre	Urban Background	Sheffield Urban Area	435134, 386885	Sheffield City Council
Southampton Centre	Urban Background	Southampton Urban Area	442565, 112255	Southampton City Council
Stockton-on-Tees - Eaglescliffe	Urban Traffic	North East	441620, 513673	Stockton on Tees BC
Stoke-on-Trent Centre	Urban Background	The Potteries	388348, 347894	City of Stoke on Trent Council
Wigan Centre	Urban Background	North West & Merseyside	357825, 406025	Wigan Metropolitan BC
York Fishergate	Urban Traffic	Yorkshire & Humberside	460744, 451033	City of York Council

As part of an ongoing investigation, there is also a pumped sampler operating at Marylebone Road since 2007. The pumped sampler is not part of the Non-Automatic Network.

Further details on the sites can be found on the UK Automatic Urban and Rural Network Site Information Archive at http://uk-air.defra.gov.uk/

2.1.2 Automatic Hydrocarbon Network

The sites in the Automatic Hydrocarbon Network are shown in Figure 2.

Figure 2 Map of Automatic Network sites in 2010

Table 5 Automatic Hydrocarbon Network sites in 2010.

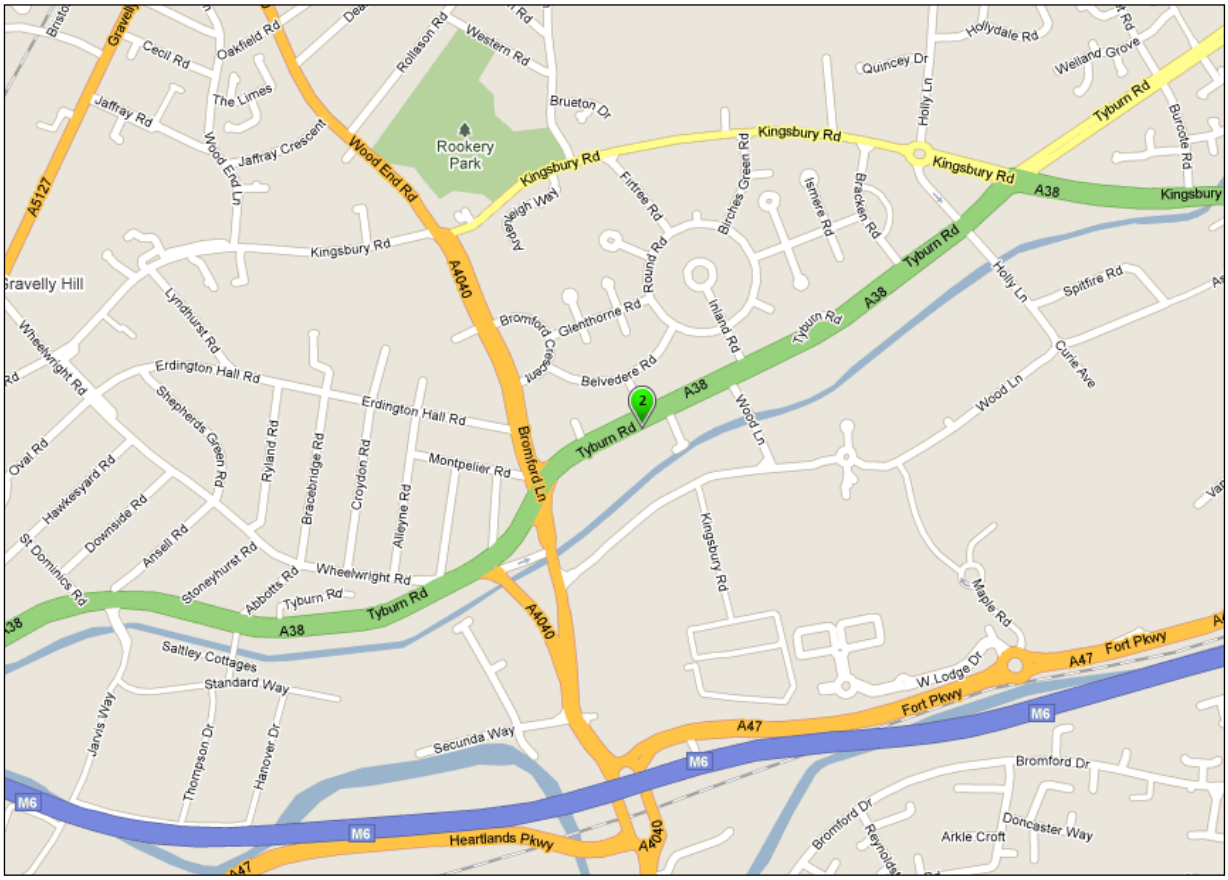
Site	Classification	Zone	Grid Ref Easting / Northing	Local Site Operator
Glasgow	Urban Traffic	Scotland	258708, 665200	Glasgow City Council/AEA
Harwell	Rural Background	South West	446772, 186020	AEA
Marylebone Road	Urban Traffic	Greater London Urban Area	528120, 182000	KCL
Auchencorth Moss	Rural Background	Scotland	322050, 656250	CEH
London Eltham	Urban Background	Greater London Urban Area	543978, 174668	Greenwich Borough Council

2.2 Changes to the Networks in 2010

2.2.1 Birmingham Roadside

In order to ensure the security and continuity of the network sites, in August 2010 the Non Automatic Hydrocarbon Network benzene sampler was moved from Birmingham Roadside 2 to Birmingham Tyburn Roadside, which is an Automatic Urban and Rural Network (AURN) site. The Birmingham Tyburn site was moved to a new site in Acocks Green on 4th May 2011 for the same reason.

Figure 3 Photograph and Location of Birmingham Tyburn Roadside, map images courtesy of Google.



2.2.2 Glasgow Kerbside

A non automatic benzene pump box was installed at Glasgow Kerbside in August 2010, to replace the automatic analyser. The two analysers were operated side by side from August until the end of December 2010, when the automatic analyser was switched off and removed from the site. A comparison of the results from these two collocated analysers is shown in Section 4.

2.2.3 Chatham Roadside

Killingholme ceased operation in 2010 and the sampler was moved to Chatham Roadside in March 2010.

2.2.4 London Eltham

A non automatic benzene pump box was installed at London Eltham in December 2010. This will operate alongside the automatic analyser throughout 2011 and the intercomparison results will be reported in the 2011 Annual Report.

2.3 Equipment Maintenance and Audits

All sites are visited by field engineers on a 6 monthly basis to calibrate the sampling flows and carry out routine maintenance of the equipment. The purpose of the audit and maintenance visits are to:

- Carry out a flow calibration using a low flow BIOS instrument
- Ensure no blockages or leaks in the system
- Clean or replace dirty filters and inspect/replace the inlet
- Replace o-rings and leak test all connections
- Carry out electrical Portable Appliance Testing (annually)
- Review the site infrastructure and surroundings
- Review health and safety risks at the site
- Change automatic GC cold trap and clean the gas generators and detectors
- Carry out a gas calibration for the automatic analysers
- Replace or refurbish non automatic sampler pumps

Non-Automatic Hydrocarbon Network benzene samplers were audited between January and April 2010. An intermediate check was carried out during July and August, and the second round of full audits and calibrations took place during October and November 2010. The schedule and results of these visits can be seen in Appendix 1. AEA received UKAS accreditation for the low flow measurement in March 2011. The measurement has not changed from the method used in 2010. The calibration data from these audits have been used to rescale the benzene concentrations during the ratification process. A copy of the certificate of accredited measurements is available in Appendix 2.

3 Data and data capture for 2010

3.1 Comparison with Limit Values and Objectives

The annual average concentration of benzene and butadiene over the calendar year 2010 is given in Table 6 and Table 7, alongside the data capture statistics. Data capture for sites where measurements started or finished during the year are calculated for the period that the equipment was operational.

Annual average concentrations at all sites were below the Limit Value of 5 µg/m^3 for benzene set by the European Ambient Air Quality Directive.

3.1.1 Non-Automatic Hydrocarbon Network

Table 6 Benzene Statistics

Site	Annual Mean Benzene (µg/m^3)	Maximum Fortnightly Mean Benzene (µg/m^3)	Data capture (%)
Barnsley Gawber	0.66	1.47	89
Bath Roadside	1.40	2.54	91
Belfast Centre	0.76	2.47	96
Birmingham Tyburn	0.81	1.92	90
Birmingham Roadside 2	1.28 [NB]	2.70	91[†]
Birmingham Tyburn Roadside	1.03 [NB]	1.73	88*
Bloomsbury	0.81	2.02	80
Bristol Old Market	1.18	2.63	98
Bury Roadside	0.90	2.15	98
Cambridge Roadside	0.83	1.89	95
Camden Kerbside	1.46 [NB]	2.70	49
Carlisle Caldewgate	1.09	2.05	93
Chatham Roadside	0.97	1.57	90
Chesterfield Roadside	0.87	1.62	88
Coventry Memorial Park	0.56	1.63	88
Eaglescliffe – Yarm	0.69	1.66	90
Glasgow Kerbside	1.17 [NB]	2.58	100[#]
Grangemouth	1.42	3.52	91
Haringey Roadside	1.13	2.00	85
Killingholme	1.61 [NB]	2.93	100[α]
Leamington Spa	0.71	1.38	88
Leeds Centre	0.71	1.37	92
Leicester Centre	0.78	1.49	96
Liverpool Speke	0.92	2.50	94
Manchester Piccadilly	0.86	2.20	98
Middlesbrough	1.19	2.44	94
Newcastle	0.59	1.50	99
Northampton	0.56	1.46	99
Norwich – Lakenfields	0.64	1.53	100
Nottingham Centre	0.83	2.02	94

Oxford Centre	0.74	1.43	98
Oxford St Ebbes	0.59	1.42	82
Plymouth Centre	0.66	1.30	91
Sheffield Centre	0.71	1.87	99
Southampton	0.86	1.69	96
Stoke Centre	1.02	1.89	93
Wigan Centre	0.77	1.72	93
York Fishergate RS	0.97	2.01	81

[NB] Data capture <75% of the year
* Monitoring started 01/09/2010
† Monitoring finished 19/08/2010
# Monitoring started 18/08/2010
α Monitoring finished 17/03/2010

Due to a short gap between the contracts of the two network managers, all sites except Norwich Lakenfields had a very short period of time at the end of June and start of July when they were not sampling. In most cases this was limited to a few days.

During 2010, the following site faults and failures were recorded:

Camden Kerbside

Between July and December, the sampler at Camden worked only when 'the tubes rested on the top of the tubing, but not when pushed down fully' according to the LSO data recording sheet. The inlet was blocked and the tubes were therefore sampling from inside the sampling enclosure for the period. The data for this period has not been reported. The fault has since been rectified.

Coventry Memorial Park

Coventry Memorial Park flow measurements were too low at the audit on 25th October 2010. The site was revisited and a new sampler was installed on 17th November 2010.

Barnsley Gawber

Barnsley Gawber - On 23rd December 2010, it was reported that there had been a flood to the changing rooms, due to a burst pipe. The sampler was switched off as a safety precaution for a short period.

Bloomsbury

At the London Bloomsbury audit 12th October 2010, AEA measured low flow from the sample excess flow and the pump diaphragm was replaced. However, the sampler continued to provide inconsistent data and the site was revisited on 9th December 2010 when the inlet tubing was found to be partially blocked. The blockage was removed and the sampler continued to work as normal.

Birmingham Tyburn and Birmingham Roadside 2

The Birmingham Tyburn and Birmingham Roadside 2 sites were not restarted until much later than other sites in July. The Birmingham Tyburn site had an electrical safety issue and the Birmingham Roadside 2 sampler was not accessible due to hazardous waste blocking the entrance.

Glasgow Kerbside

The Glasgow pump box was installed at the Glasgow Kerbside site on 18th August 2010.

Oxford St Ebbes

The Oxford St Ebbes health light stopped flashing during the first week of running the network. The sample flow was very low. A field engineer was sent out to install a new pump, which did not rectify the fault. A second engineer visited the site on 3rd November 2010 for a routine audit to find the inlet tubing was blocked. The blockage was removed and the flow returned to normal.

York Fishergate

The flow adjustment potentiometer could not be adjusted at York Fishergate on 7th October 2010. This fault did not affect data capture or data quality.

3.1.1 Automatic Hydrocarbon Network

Table 7 Benzene and 1,3-butadiene Statistics

Site	Pollutant	Annual Mean (µg/m^3)	Maximum (µg/m^3)	Data capture	Data quality code
Glasgow	Benzene	1.03	12.1	96%	A
	1,3-Butadiene	0.08	3.91	96%	A
Harwell	Benzene	0.50	3.21	65%	B
	1,3-Butadiene	0.11	0.40	51%	B
Marylebone Road	Benzene	1.23	13.0	67%	B
	1,3-Butadiene	0.38	10.7	71%	B
Auchencorth Moss	Benzene	0.31	3.31	77%	A
	1,3-Butadiene	0.03	0.34	28%	A
London Eltham	Benzene	0.57	7.36	80%	A
	1,3-Butadiene	0.08	1.50	80%	A

Annual Mean concentrations for all measured hydrocarbons at all sites are given in Appendix 3.

Data quality codes are used to assign a level of confidence in the hydrocarbon data. In general ratified hourly data have an uncertainty (at 95% confidence) of ±10% for values above 0.5 µg/m^3 and ±0.05 µg/m^3 for values below 0.5 µg/m^3. These data are termed “good quality” and the data quality code is A.

In some cases, because of instruments problems, data cannot be described as “good” quality, but the data might still be of use to modellers and is therefore included in the dataset. These data are termed “acceptable” quality data and have an uncertainty (at 95% confidence) of ±25% for values above 0.5 µg/m^3 and ±0.1 µg/m^3 for values below 0.5 µg/m^3. The data quality code for acceptable data is B.

Data that does not meet either the “good” or “acceptable” criteria is deleted during ratification.

Harwell

There is an ongoing issue at the Harwell site, where a collocated Condensation Particle Counter, which uses butanol, causes contamination of the benzene, 1,3-butadiene and 1-butene peaks in the GC. This was particularly evident from April to October 2010, and many of the chromatographs could not resolve the co-eluting peaks. It resulted in significant data loss during this period. An investigation into this issue and possible solutions is underway in 2011.

Marylebone Road

There were two key faults which affected the data at Marylebone Road during 2010. In March, significant data were deleted during ratification due to poor chromatography following a service. In May and June a hydrogen generator fault caused further data loss. These issues have both been rectified.

Auchencorth Moss

At Auchencorth Moss there are ongoing issues with data loss due to the very low ambient levels of hydrocarbons, which are often below the limit of detection. During 2010, measurements which were below the limit of detection for any species were not reported and this has had an impact on the data capture. However, from 2011 and in accordance with the European Standard[2] measurements below the limit of detection will be reported as a concentration equal to half of the detection limit. This will improve data capture in future years.

Furthermore, at Auchencorth Moss, the analyser suffered a detector fault in April and a hydrogen generator fault in October.

London Eltham

There were three separate faults with the analyser at Eltham during 2010. In January some data were lost due to a hydrogen generator fault. In June, the analyser suffered a detector breakdown and the sample pump failed in October. All issues were rectified promptly but overall 20% data was lost during the year.

[2] EN14662-3:2005 Ambient Air Quality Standard method for the measurements of benzene concentrations – Part 3: Automated pumped sampling with in-situ gas chromatography

3.2 Concentration Trends

3.2.1 Trends in 2010

Time series graphs for benzene and 1,3 butadiene are available in Appendix 4. The majority of Traffic Urban and Background Urban sites show a distinct trend with benzene concentrations highest in the winter months, and lowest around July to September. At Urban and Rural sites there tends to be a pattern of seasonal variation with higher levels during the winter when dispersion is generally poorer and photochemical removal is at a minimum. This trend is less evident at Industrial sites including Middlesbrough and Grangemouth, where the emissions from the industry are significant.

3.2.2 Long Term Trends

Figures 4 to 5 show annual mean benzene concentrations at long running sites from the Non-Automatic Hydrocarbon Network. Concentrations have dropped significantly since the start of this network in 2002, but appear to be levelling out over the past couple of years.

Figure 4 Long term Non-Automatic benzene trends – higher concentration sites

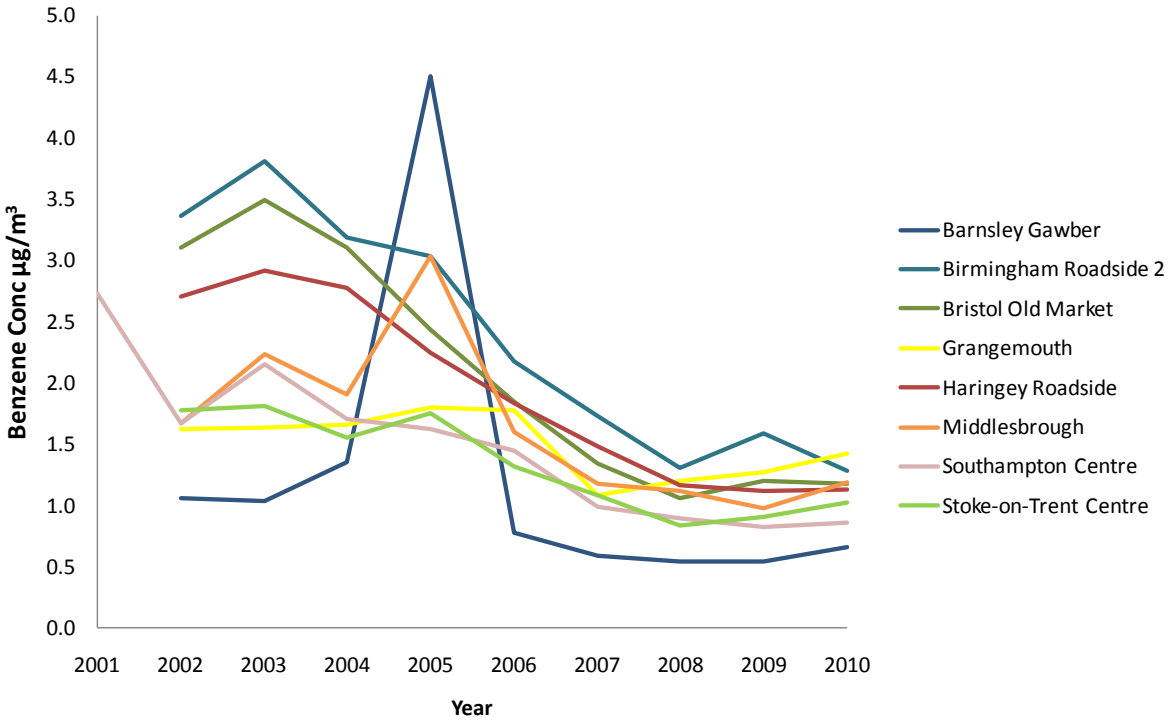


Figure 5 Long term Non-Automatic benzene trends – lower concentration sites

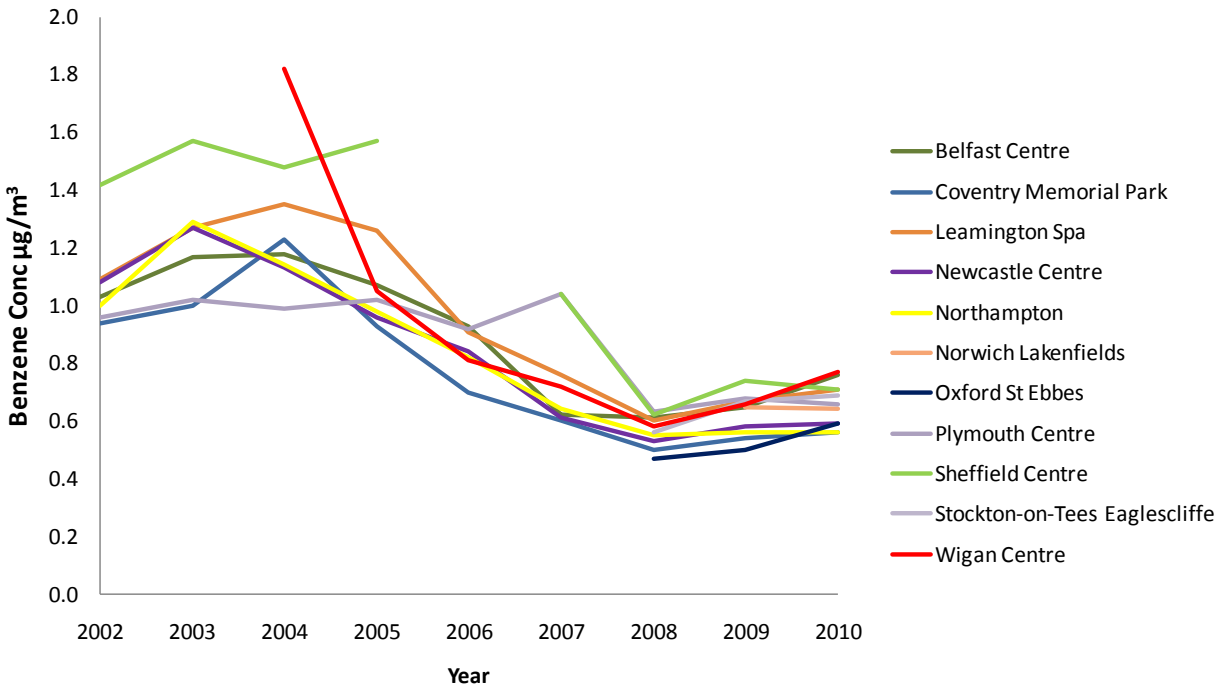
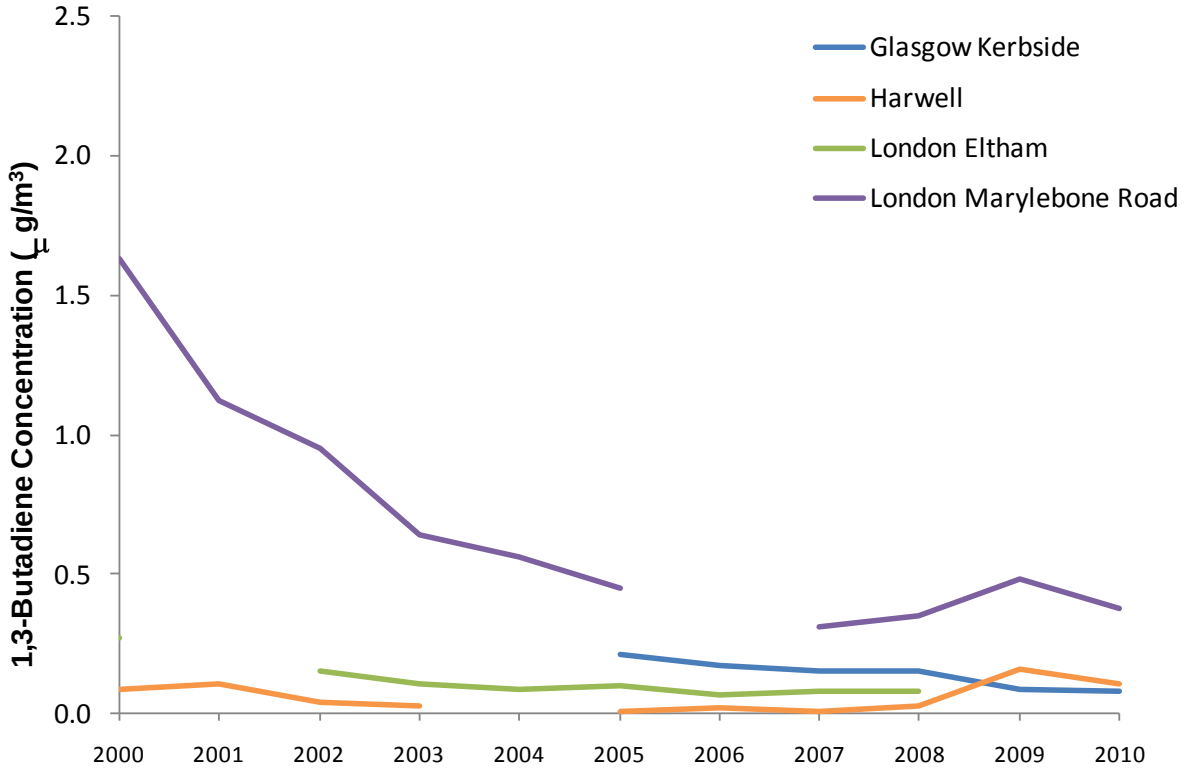


Figure 6 and Figure 7 show the long-term trends of the annual mean concentrations of benzene and 1,3-butadiene at the four sites with long running datasets within the Automatic Hydrocarbon Network. Note that in 2010 annual mean benzene concentrations for Harwell and Marylebone Road are based on 65% and 67% data capture respectively. In other years no data are included where the data capture in the year was less than 75%.

Figure 6 Long term Automatic benzene trends

Note that in 2010 annual mean 1,3 butadiene concentrations for Harwell and Marylebone Road are based on 51% and 71% data capture respectively. In other years no data are included where the data capture in the year was less than 75%.

Figure 7 Long term Automatic 1,3-butadiene trends



4 Data Quality

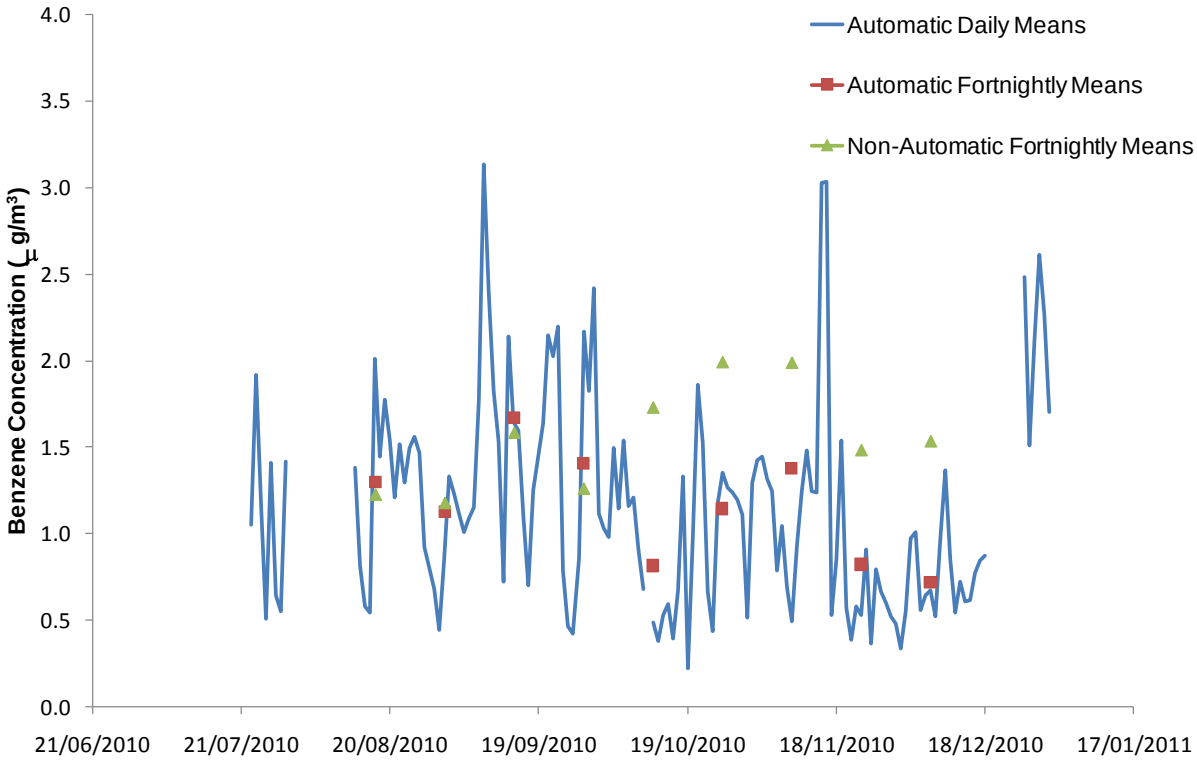
4.1 Intercomparisons

In 2010 there were two sites at which Non-Automatic samplers and Automatic analysers were collocated. These sites were Marylebone Road and Glasgow Kerbside. Comparing data from collocated samplers is a good way to validate the data. Comparisons from these two sites are shown below.

4.1.1 Marylebone Road

Data is available from the two collocated samplers at Marylebone Road in 2010. Figure 8 shows the daily mean concentrations from the automatic analyser and a fortnightly mean which has been calculated from the daily means (only where data capture >75%). These automatic fortnightly means correspond to the dates of sampling with the non-automatic benzene samplers, so the data may be directly compared.

Figure 8 Comparison of collocated samplers at Marylebone Road



Within the uncertainty of the measurements (see Section 4.2) it can be seen that the two measurement methods agree well with each other for a period during August and September 2010. However, from October until the end of the year the non-automatic sampler measured significantly higher benzene concentrations than the automatic analyser at the site. This is very similar to the results seen in previous years. Investigations are ongoing, but it is believed to be linked to high levels of butanol inside the Marylebone Road site. Butanol co-elutes with the benzene peak in the chromatograph. In the ambient sample, the butanol and

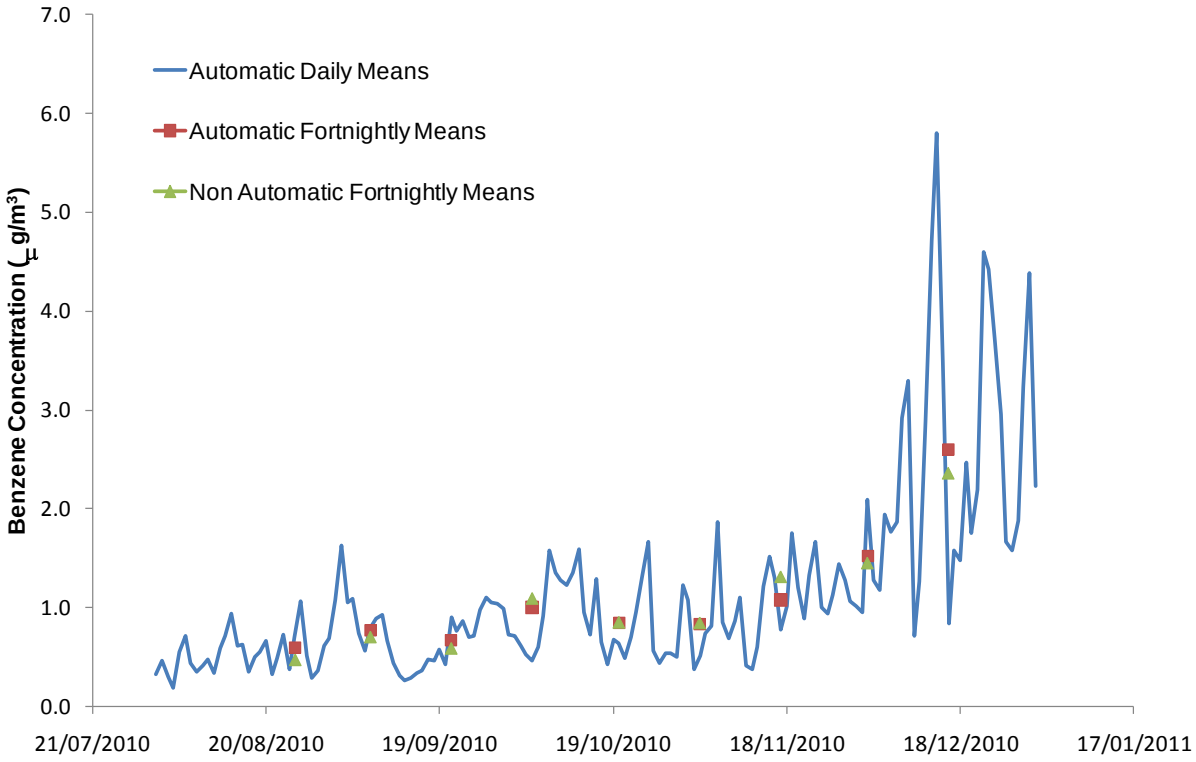
benzene peaks in the chromatograph are usually well enough resolved that they can be separated, but in some cases the peaks cannot be resolved in the calibration peak, which leads to an under-estimation of the ambient benzene.

This theory has not yet been proven but AEA is currently undertaking a study at the Harwell site which will investigate the butanol contamination more thoroughly.

4.1.2 Glasgow Kerbside

Data from the collocated samplers at Glasgow Kerbside during the last six months of the year have been compared in a similar way and are presented in Figure 9

Figure 9 Comparison of collocated samplers at Glasgow Kerbside



Within the uncertainty of the measurements it can be seen that the two measurement methods agree well with each other for the entire period that the two samplers were collocated in 2010. It should be noted that the measurement methods at Glasgow and Marylebone Road are not entirely identical due to the difference in automatic analyser; however there is also no butanol present at the Glasgow Kerbside site, which supports the theory that this is the reason for the disagreement at Marylebone Road.

4.2 Estimation of Uncertainty

Calculated uncertainty for the Non-Automatic Hydrocarbon Network from January to June inclusive, for benzene is 12%, expressed at a level of confidence of 95%. This includes NPL's field audits and analysis uncertainty.

Calculated uncertainty for the Non-Automatic Hydrocarbon Network from July to December inclusive, for benzene is 15%, expressed at a level of confidence of 95%. This includes contributions from AEA's flow measurements, desorption efficiency and analysis uncertainty.

All data from the network therefore meet the 2008/50/EC Directive Data Quality Objective for the measurement uncertainty of ±25%.

The uncertainty estimation for the automatic analyser includes a number of components and a full uncertainty budget is currently under development.

4.3 Standard Methods

European Standard EN14662-3:2005 is the Ambient Air Quality Standard method for the measurements of benzene concentrations – Part 3: Automated pumped sampling with in-situ gas chromatography. This Standard is for the determination of benzene in ambient air for the purpose of comparing measurement results with annual mean limit values. It describes guidelines for measurements with automated gas chromatographs, between 0 and 50 µg/m^3. Measurements undertaken by the Automatic Hydrocarbon Network are carried out in accordance with this Standard.

European Standard EN14662-1:2005 is the Ambient Air Quality Standard method for measurement of benzene concentrations – Part 1: Pumped sampling followed by thermal desorption and gas chromatography. This Standard gives general guidance for the sampling and analysis of benzene in air by pumped sampling, thermal desorption and capillary gas chromatography. The pumped sampler was developed by NPL in compliance with this standard. AEA contract Environmental Scientifics Groups (ESG) to analyse the samples, the analysis is also carried out in accordance with this standard.

4.4 Limit of Detection

The Limit of Detection for the mass of benzene on a desorption tube from the Non-Automatic Hydrocarbon Network is approximately 2ng. This is equivalent to about 0.02 µg/m^3

The Limit of Detection for each species measured by the Perkin Elmer Ozone Precursor Analysers and Environnement VOC71M analysers used by the Automatic Hydrocarbon Network is shown in Table 8.

Table 8 Automatic Analyser Limits of Detections

Compound	Limit of Detection (µg/m^3)
Ethane	0.10
Ethene	0.01
Propane	0.02
Propene	0.02
Ethyne	0.01
i-Butane	0.02
n-Butane	0.02
trans-2-Butene	0.02
1-Butene	0.02
cis-2-Butene	0.02
i-Pentane	0.03
n-Pentane	0.03
1,3-Butadiene	0.02
trans-2-Pentene	0.03
1-Pentene	0.03
2-Methylpentane	0.04
Isoprene	0.03
n-Hexane	0.04
Benzene	0.03
i-Octane	0.05
n-Heptane	0.04
n-Octane	0.05
Toluene	0.04
Ethylbenzene	0.04
(m+p)-Xylene	0.04
o-Xylene	0.04
1,3,5-Trimethylbenzene	0.05
1,2,4-Trimethylbenzene	0.05
1,2,3-Trimethylbenzene	0.05

5 Developments and Recommendations

5.1 EN14662-3:2005

European Standard EN14662-3:2005 is likely to be reviewed by Working Group 12 later in 2011, to bring it in line with the other gaseous pollutants' standards. AEA will be involved in the review through a representative on the Working Group, and will provide appropriate contributions and feedback to Defra and the Devolved Administrations regarding the potential implications for the Automatic Hydrocarbon Network.

5.2 Acetaldehyde and Formaldehyde

The UK Air Quality Expert Group (AQEG) have recently published an advice note on road transport biofuels and their impact on UK air quality for Defra and the Devolved Administrations. The AQEG note can be found at http://uk-air.defra.gov.uk/documents/110322_AQEG_Biofuels_advice_note.pdf.

The note accepts that results from research studies on the effects of biofuels on vehicle emission are inconclusive and show a high degree of variability, but concludes that any increased use of bioethanol and biodiesel are likely to significantly increase acetaldehyde and formaldehyde emissions. The note goes on to say that 'the likely continued growth in biofuel consumption in the UK means that evidence for any atmospheric change in pollutant concentrations should be monitored in parallel with direct measurements of biofuel emissions from road vehicles'.

AEA recommends that Defra and the DAs consider monitoring acetaldehyde and formaldehyde at a small number of roadside sites in the Non Automatic Hydrocarbon Network which are collocated with NOx and PM analysers. This will help the UK to prepare for potential legislative change in the future and will start a dataset useful for long term trend analysis.

5.3 Network Review

Under Article V to Article VII of Directive 2008/50/EC all Member States must carry out a periodic review of monitoring networks. In the UK, this assessment is taking place in 2011 and the results of this review, thought to be complete in early 2012, will be used by Defra and the DAs and the Network contractor to make any recommended changes to the Non Automatic and Automatic Hydrocarbon Networks.

AirMonTech is an EU Coordination and Support Action funded under the EU Seventh Framework Programme. It was established in 2010 to provide relevant information to air quality monitoring network operators and stakeholders on current and recently developed monitoring technologies, to identify future needs for improvement of the air quality monitoring networks, and to give advice on a corresponding research road map. The results of the project are expected to provide important input to the revision of the European air quality directives foreseen to start in 2013. In turn, this will affect the future monitoring requirements for these Hydrocarbon Networks.

Appendices

Appendix 1: 2010 Audit Schedule and Results

Appendix 2: Copy of 2011 audit certificate - Accredited low flow measurements

Appendix 3: Data capture, maximum and annual mean values from the Automatic Hydrocarbon Network

Appendix 4: 2010 Benzene and 1,3-Butadiene Concentration data

Appendix 1

Audit Schedule of the Non-Automatic Hydrocarbon Network

Table 9 Audit Schedule of the Non-Automatic Hydrocarbon Network

Site	Date	Adjusted flow, ml/min	Date	Measured flow, ml/min	Adjusted flow, ml/min	Date	Measured flow, ml/min	Adjusted flow, ml/min
Barnsley Gawber	02/03/2010	10.00	19/10/10	10.78	10.03	12/04/11	9.80	10.07
Bath Roadside	20/04/2010	10.00	27/10/10	9.71	9.74	15/04/11	9.57	9.80
Belfast Centre	27/01/2010	10.01	25/10/10	11.17	10.13	18/04/11	10.18	10.07
Birmingham Roadside 2	08/01/2010	10.00	19/08/10	10.81	NA	NA	NA	NA
Birmingham Tyburn	08/01/2010	10.00	13/10/10	10.02	10.02	04/05/11	10.20	NA
Birmingham Tyburn Roadside	-	-	13/10/10	NA	10.04	04/05/11	9.98	10.00
Bloomsbury	08/04/2010	9.91	12/10/10	10.56	10.01	16/05/11	9.97	10.00
Bristol Old Market	20/04/2010	10.00	02/11/10	9.77	9.75	05/05/11	9.82	9.95
Bury Roadside	26/01/2010	10.00	06/10/10	11.30	10.07	04/05/11	10.23	10.10
Cambridge Roadside	19/01/2010	10.02	21/10/10	10.23	10.01	12/05/11	10.16	10.06
Camden Kerbside	27/04/2010	10.00	18/10/10	10.36	10.36	07/08/11	10.95	10.08
Carlisle Caldewgate	18/03/2010	10.23	11/10/10	10.83	10.01	06/05/11	10.31	10.01
Chatham Roadside	25/03/2010	10.00	27/10/10	10.70	10.04	05/04/11	9.63	9.61
Chesterfield	16/03/2010	9.96	07/10/10	10.58	10.03	13/04/11	10.19	9.94
Coventry Memorial Park	09/03/2010	10.00	25/10/10	10.23	10.23	07/04/11	9.80	10.00
Eaglescliffe – Yarm	15/03/2010	10.23	11/10/10	10.49	9.97	05/04/11	10.20	10.10
Glasgow Kerbside	-	-	21/10/10	10	10.01	14/04/11	9.77	10.00

Grangemouth	18/03/2010	10.23	21/10/10	11.62	10.00	11/04/11	9.5	10.00
Haringey Roadside	02/02/2010	10.07	09/12/10	10	9.80	16/05/11	9.78	9.96
Leamington Spa	09/03/2010	9.96	25/10/10	10.25	10.01	07/04/11	9.90	10.00
Leeds Centre	02/03/2010	10.05	20/10/10	10.45	9.97	12/04/11	9.80	9.91
Leicester Centre	16/02/2010	10.00	17/11/10	11.76	10.00	04/04/11	10.00	10.10
Liverpool Speke	12/01/2010	10.02	25/10/10	10.40	10.00	05/04/11	10.30	10.00
Manchester Piccadilly	26/01/2010	9.96	18/10/10	10.73	10.03	04/05/11	10.12	10.03
Marylebone Rd (non-network site)	27/04/2010	10.00	12/10/10	10.69	10.02	16/05/11	9.9	10.11
Middlesbrough	16/03/2010	10.23	12/10/10	10.87	10.01	05/04/11	10.50	10.10
Newcastle	16/03/2010	10.23	12/10/10	11.42	10.02	04/04/11	10.10	10.00
Northampton	17/02/2010	9.96	11/10/10	10.88	9.97	06/04/11	9.9	10.00
Norwich - Lakenfields	28/04/2010	9.87	12/10/10	10.22	10.00	13/04/11	7.77*	10.00
Nottingham Centre	16/02/2010	9.99	13/10/10	10.75	10.02	13/04/11	10.16	9.94
Oxford Centre	05/01/2010	9.96	18/10/10	10.66	10.03	06/05/11	10.20	10.10
Oxford St Ebbes	05/01/2010	10.00	03/11/10	11.74	9.95	06/05/11	9.83	9.89
Plymouth	21/04/2010	10.00	18/10/10	10.66	10.03	18/04/11	9.79	9.93
Sheffield	16/03/2010	9.96	19/10/10	10.62	10.04	12/04/11	10.15	10.00
Southampton	03/02/2010	10.05	26/10/10	10.52	10.01	05/04/11	10.10	10.00
Stoke Centre	13/01/2010	10.00	26/10/10	10.69	10.00	06/04/11	9.80	10.00
Wigan Centre	26/01/2010	10.00	25/10/10	10.35	9.98	05/04/11	10.40	9.90
York Fishergate Roadside	02/03/2010	10.00	07/10/10	10.16	10.51	11/04/11	9.39	9.94

*Sampler and pump replaced, pump fault

2010 Audit Schedule of the Automatic Hydrocarbon Network

Table 10 Audit and Service Schedule of the Automatic Hydrocarbon Network

Site	Service Date	Audit Date	Audit Date
Auchencorth Moss	03/02/10	04/11/09	18/05/11
Harwell	21/04/10	26/10/09	14/03/11
Eltham	12/11/10	27/10/09	16/03/11
Marylebone Road	05/03/10	28/10/09	15/03/11
Glasgow	03/09/09	03/09/09	-

Appendix 2

Copy of 2011 Audit certificate - Accredited low flow measurements

AEA

Certificate of Calibration

UKAS CALIBRATION

0401

AEA, 551.11 Harwell IBC, Didcot, Oxfordshire OX11 0QJ 01235 436465

Certificate Number: 2454

Approved Signatories: S Eaton, J Green, D Hector, B Stacey, S Stratton

Signed: This copy is representative of the official certificate

Date of issue: 31 May 2011

Customer Name and Address:
Dr Emily Connolly
Science and Evidence Team
Atmosphere and Local Environment (ALE) Programme
Department for Environment, Food and Rural Affairs
Area 5E Ergon House, 17 Smith Square, London, SW1P 3JR

Description: Measured flow rates for samplers in the Non-Automatic Hydrocarbon Monitoring Network

Measured flowrates

Site	Date of measurement	Flow A ($mlmin^{-1}$)	Flow B ($mlmin^{-1}$)	Difference ($mlmin^{-1}$)	Uncertainty ($mlmin^{-1}$)
Barnsley Gawber	12/04/2011	10.07	10.20	0.13	0.004
Bath Roadside	15/04/2011	9.80	9.80	0.00	0.002
Belfast Centre	18/04/2011	10.07	10.14	0.07	0.003
Birmingham Acocks Green*	04/05/2011	10.10	10.10	0.00	0.002
Birmingham Tyburn Roadside	04/05/2011	10.00	10.02	0.02	0.002
London Bloomsbury	16/05/2011	10.00	9.99	0.01	0.002
Bristol Old Market	05/05/2011	9.95	9.94	0.01	0.002
Bury Roadside	04/05/2011	10.10	10.15	0.05	0.003
Cambridge Roadside	12/05/2011	10.06	10.07	0.01	0.002
Camden Kerbside	07/08/2011	10.08	10.13	0.05	0.003
Carlisle Roadside	06/05/2011	10.01	10.09	0.08	0.003
Chatham Centre Roadside	05/04/2011	9.61	9.60	0.01	0.002
Chesterfield Roadside	13/04/2011	9.94	10.03	0.09	0.004
Coventry Memorial Park	07/04/2011	10.00	10.00	0.00	0.002
Glasgow Kerbside	14/04/2011	10.03	10.08	0.05	0.003
Grangemouth	12/04/2011	10.00	10.08	0.08	0.003
Haringey Roadside	16/05/2011	9.96	9.99	0.03	0.003
Leamington Spa	07/04/2011	9.96	9.97	0.01	0.002
Leeds Centre	12/04/2011	9.91	9.95	0.04	0.003

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95% The uncertainty evaluation has been carried out in accordance with UKAS requirements.

AEA

Certificate Number: 2454

UKAS CALIBRATION 0401

Site	Date of measurement	Flow A ($mlmin^{-1}$)	Flow B ($mlmin^{-1}$)	Difference ($mlmin^{-1}$)	Uncertainty ($mlmin^{-1}$)
Leicester Centre	04/04/2011	10.12	10.12	0.00	0.002
Liverpool Speke	05/04/2011	9.97	9.97	0.00	0.002
Manchester Piccadilly	04/05/2011	10.03	10.11	0.08	0.003
Marylebone Road	19/04/2011	10.11	10.04	0.07	0.003
Middlesbrough Centre	05/04/2011	10.10	10.10	0.00	0.002
Newcastle Centre	04/04/2011	10.01	10.09	0.08	0.003
Northampton	06/04/2011	10.00	10.00	0.00	0.002
Norwich Lakenfields	12/05/2011	10.04	10.04	0.00	0.002
Nottingham Centre	13/04/2011	9.94	10.01	0.07	0.003
Oxford Centre	06/05/2011	10.22	10.21	0.01	0.002
Oxford St Ebbes	06/05/2011	9.89	9.89	0.00	0.002
Plymouth Centre	18/04/2011	9.93	9.93	0.00	0.002
Sheffield Centre	12/04/2011	10.00	10.06	0.06	0.003
Southampton	05/04/2011	10.03	10.02	0.01	0.002
Stockton-on-Tees Eaglescliffe	05/04/2011	10.10	10.10	0.00	0.002
Stoke-on-Trent Centre	06/04/2011	9.96	9.97	0.01	0.002
Wigan Centre	05/04/2011	10.00	9.90	0.10	0.004
York Fishergate	11/04/2011	9.94	9.95	0.01	0.002

*The sampler at Birmingham Tyburn was removed and installed at Birmingham Acocks Green on the same day.

The measured flow rate (where this is applicable) is the flow rate through the two sample tubes on the day of audit using documented methods. Flows are corrected to 20°C and 1 atm. . Note that the test results are valid on the day of test only, as flowrate drift over time cannot be quantified.

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2 , providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

Appendix 3

Data capture, maximum and annual mean values from the Automatic Hydrocarbon Network

Percentage data capture, maximum and annual mean values of ratified data from the Auchencorth Moss site of the Automatic Hydrocarbon Network. Note that the annual mean concentrations have been calculated even where the data capture at the site is less than 75%. These annual means therefore may not be representative of an average year and the data should be used with caution.

Table 11 Auchencorth Moss

Compound	% Data capture	Maximum hourly concentration (µg/m^3)	Annual Mean concentration (µg/m^3)
Ethane	80	26.2	2.30
Ethene	58	4.16	0.35
Propane	80	188	1.86
Propene	50	6.34	0.17
Ethyne	67	1.96	0.25
i-Butane	75	67.6	0.58
n-Butane	76	166	1.00
trans-2-Butene	<LoD	<LoD	<LoD
1-Butene	<LoD	<LoD	<LoD
cis-2-Butene	<LoD	<LoD	<LoD
i-Pentane	74	56.2	0.40
n-Pentane	72	34.6	0.27
1,3-Butadiene	28	0.34	0.03
trans-2-Pentene	<LoD	<LoD	<LoD
1-Pentene	<LoD	<LoD	<LoD
2-Methylpentane	54	7.65	0.09
Isoprene	10	1.67	0.08
n-Hexane	58	14.1	0.12
Benzene	77	3.31	0.31
i-Octane	20	1.80	0.08
n-Heptane	33	3.53	0.09
n-Octane	7	0.66	0.04
Toluene	67	9.18	0.24
Ethylbenzene	25	1.37	0.08
(m+p)-Xylene	26	4.67	0.16
o-Xylene	22	1.41	0.08
1,3,5-Trimethylbenzene	<LoD	<LoD	<LoD
1,2,4-Trimethylbenzene	<LoD	<LoD	<LoD
1,2,3-Trimethylbenzene	<LoD	<LoD	<LoD

Percentage data capture, maximum and annual mean values of ratified data from the Glasgow site of the Automatic Hydrocarbon Network.

Table 12 Glasgow

Compound	% Data capture	Maximum hourly concentration (µg/m^3)	Annual Mean concentration (µg/m^3)
Ethane	Not measured	Not measured	Not measured
Ethene	Not measured	Not measured	Not measured
Propane	Not measured	Not measured	Not measured
Propene	Not measured	Not measured	Not measured
Ethyne	Not measured	Not measured	Not measured
i-Butane	Not measured	Not measured	Not measured
n-Butane	Not measured	Not measured	Not measured
trans-2-Butene	Not measured	Not measured	Not measured
1-Butene	Not measured	Not measured	Not measured
cis-2-Butene	Not measured	Not measured	Not measured
i-Pentane	Not measured	Not measured	Not measured
n-Pentane	Not measured	Not measured	Not measured
1,3-Butadiene	96	3.91	0.08
trans-2-Pentene	Not measured	Not measured	Not measured
1-Pentene	Not measured	Not measured	Not measured
2-Methylpentane	Not measured	Not measured	Not measured
Isoprene	Not measured	Not measured	Not measured
n-Hexane	Not measured	Not measured	Not measured
Benzene	96	12.1	1.03
i-Octane	Not measured	Not measured	Not measured
n-Heptane	Not measured	Not measured	Not measured
n-Octane	Not measured	Not measured	Not measured
Toluene	96	84.3	2.43
Ethylbenzene	83	10.2	0.47
(m+p)-Xylene	95	35.3	1.68
o-Xylene	85	11.7	0.64
1,3,5-Trimethylbenzene	Not measured	Not measured	Not measured
1,2,4-Trimethylbenzene	Not measured	Not measured	Not measured
1,2,3-Trimethylbenzene	Not measured	Not measured	Not measured

Percentage data capture, maximum and annual mean values of ratified data from the Harwell site of the Automatic Hydrocarbon Network. Note that the annual mean concentrations have been calculated even where the data capture at the site is less than 75%. These annual means therefore may not be representative of an average year and the data should be used with caution.

Table 13 Harwell

Compound	% Data capture	Maximum hourly concentration (µg/m^3)	Annual Mean concentration (µg/m^3)
Ethane	92	23.6	2.99
Ethene	87	5.83	0.59
Propane	91	27.7	1.82
Propene	88	4.99	0.34
Ethyne	89	2.78	0.36
i-Butane	82	6.27	0.64
n-Butane	91	19.5	1.01
trans-2-Butene	83	0.28	0.08
1-Butene	53	1.70	0.17
cis-2-Butene	73	0.19	0.05
i-Pentane	92	5.57	0.52
n-Pentane	92	2.60	0.29
1,3-Butadiene	51	0.40	0.11
trans-2-Pentene	<LoD	<LoD	<LoD
1-Pentene	<LoD	<LoD	<LoD
2-Methylpentane	91	3.61	0.16
Isoprene	37	1.39	0.05
n-Hexane	91	5.29	0.14
Benzene	65	3.21	0.50
i-Octane	49	1.23	0.14
n-Heptane	64	0.71	0.11
n-Octane	50	0.43	0.07
Toluene	84	13.9	0.68
Ethylbenzene	68	1.28	0.12
(m+p)-Xylene	75	4.72	0.28
o-Xylene	72	1.90	0.15
1,3,5-Trimethylbenzene	25	1.15	0.11
1,2,4-Trimethylbenzene	77	1.35	0.15
1,2,3-Trimethylbenzene	65	0.80	0.09

Percentage data capture, maximum and annual mean values of ratified data from the London Eltham site of the Automatic Hydrocarbon Network. Note that the annual mean concentrations have been calculated even where the data capture at the site is less than 75%. These annual means therefore may not be representative of an average year and the data should be used with caution.

Table 14 London Eltham

Compound	% Data capture	Maximum hourly concentration (µg/m^3)	Annual Mean concentration (µg/m^3)
Ethane	76	81.7	6.68
Ethene	72	15.0	0.84
Propane	79	47.7	3.02
Propene	79	8.19	0.37
Ethyne	79	4.93	0.42
i-Butane	80	30.3	1.52
n-Butane	80	53.6	2.90
trans-2-Butene	80	2.05	0.12
1-Butene	68	1.02	0.09
cis-2-Butene	80	1.30	0.08
i-Pentane	80	34.8	1.69
n-Pentane	80	18.4	0.72
1,3-Butadiene	80	1.50	0.08
trans-2-Pentene	79	1.86	0.07
1-Pentene	79	0.67	0.04
2-Methylpentane	80	8.55	0.39
Isoprene	77	3.45	0.17
n-Hexane	80	16.1	0.29
Benzene	80	7.36	0.57
i-Octane	83	8.67	0.29
n-Heptane	83	23.8	0.18
n-Octane	79	0.66	0.08
Toluene	83	26.9	1.39
Ethylbenzene	83	4.50	0.24
(m+p)-Xylene	83	14.6	0.73
o-Xylene	83	5.33	0.27
1,3,5-Trimethylbenzene	74	1.45	0.11
1,2,4-Trimethylbenzene	82	5.49	0.36
1,2,3-Trimethylbenzene	80	4.29	0.25

Percentage data capture, maximum and annual mean values of ratified data from the Marylebone Road site of the Automatic Hydrocarbon Network. Note that the annual mean concentrations have been calculated even where the data capture at the site is less than 75%. These annual means therefore may not be representative of an average year and the data should be used with caution.

Table 15 Marylebone Road

Compound	% Data capture	Maximum hourly concentration (µg/m^3)	Annual Mean concentration (µg/m^3)
Ethane	74	144	9.14
Ethene	71	19.3	2.56
Propane	74	178	4.59
Propene	72	7.07	1.45
Ethyne	69	10.3	1.26
i-Butane	74	53.0	2.62
n-Butane	74	38.9	4.70
trans-2-Butene	70	2.17	0.24
1-Butene	52	1.56	0.39
cis-2-Butene	67	1.51	0.20
i-Pentane	73	88.3	5.07
n-Pentane	73	17.6	1.63
1,3-Butadiene	71	10.7	0.38
trans-2-Pentene	47	7.68	0.36
1-Pentene	45	4.31	0.23
2-Methylpentane	70	70.2	2.09
Isoprene	64	22.0	0.35
n-Hexane	72	13.2	0.54
Benzene	67	13.0	1.23
i-Octane	71	13.1	0.78
n-Heptane	71	11.4	0.42
n-Octane	65	7.30	0.15
Toluene	74	118	4.28
Ethylbenzene	76	8.37	0.77
(m+p)-Xylene	75	37.6	2.44
o-Xylene	75	13.8	0.91
1,3,5-Trimethylbenzene	66	6.98	0.42
1,2,4-Trimethylbenzene	74	8.08	1.09
1,2,3-Trimethylbenzene	75	3.89	0.43

Appendix 4

Automatic Hourly Mean Graphs for Benzene and 1,3-Butadiene

Figure 10 Auchencorth Moss Automatic Benzene

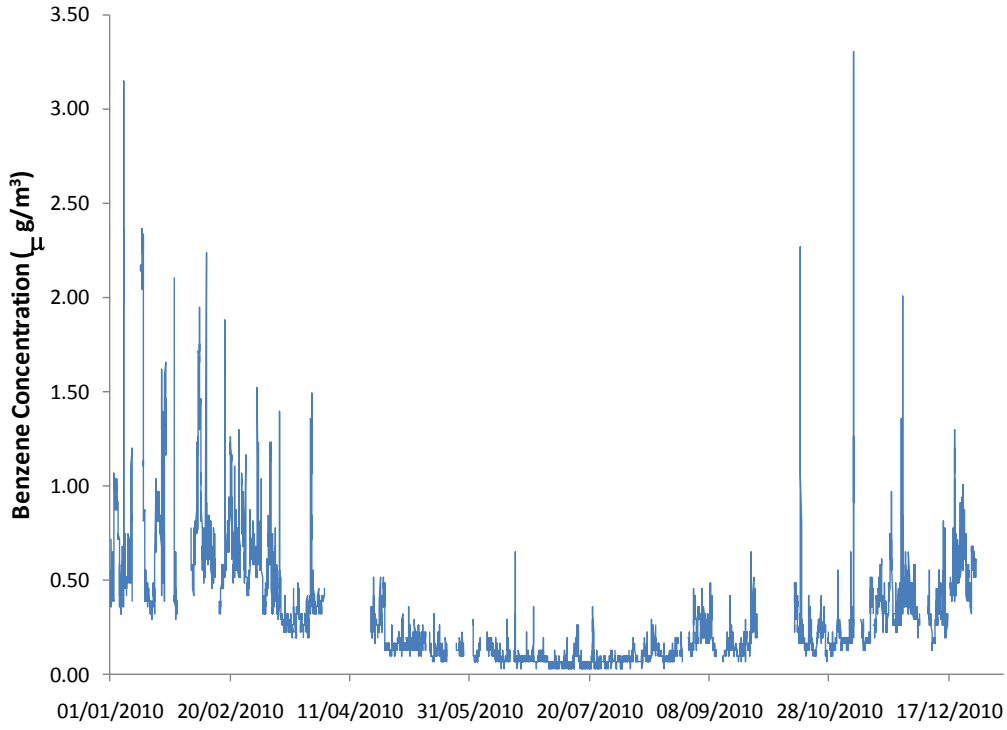


Figure 11 Auchencorth Moss Automatic 1,3-Butadiene

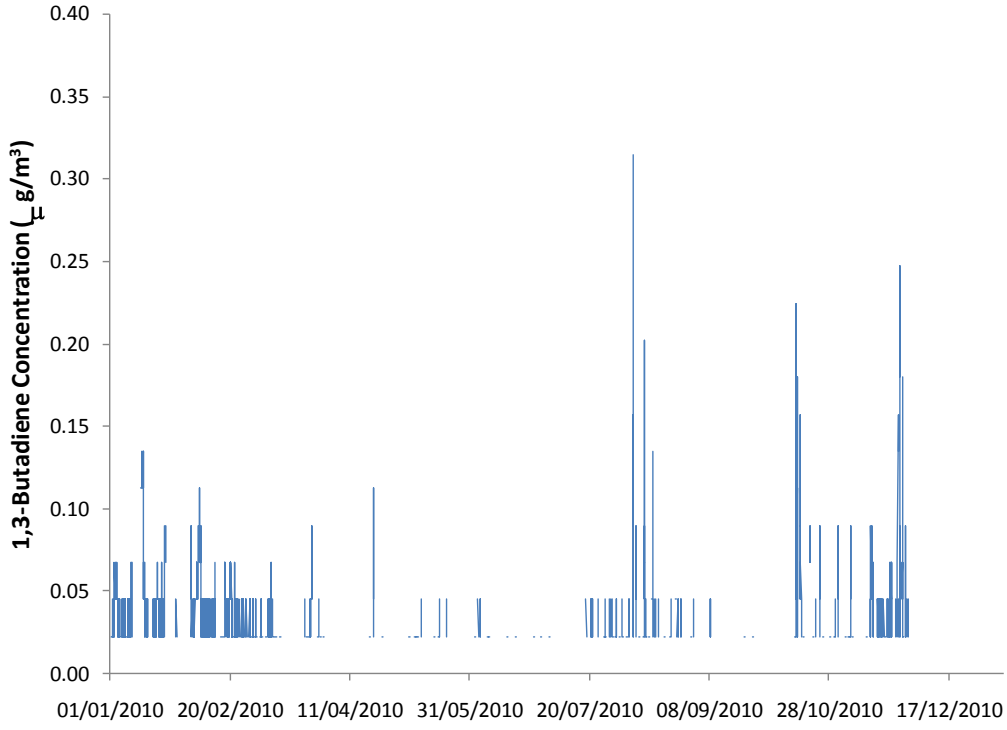


Figure 12 Glasgow Kerbside Automatic Benzene

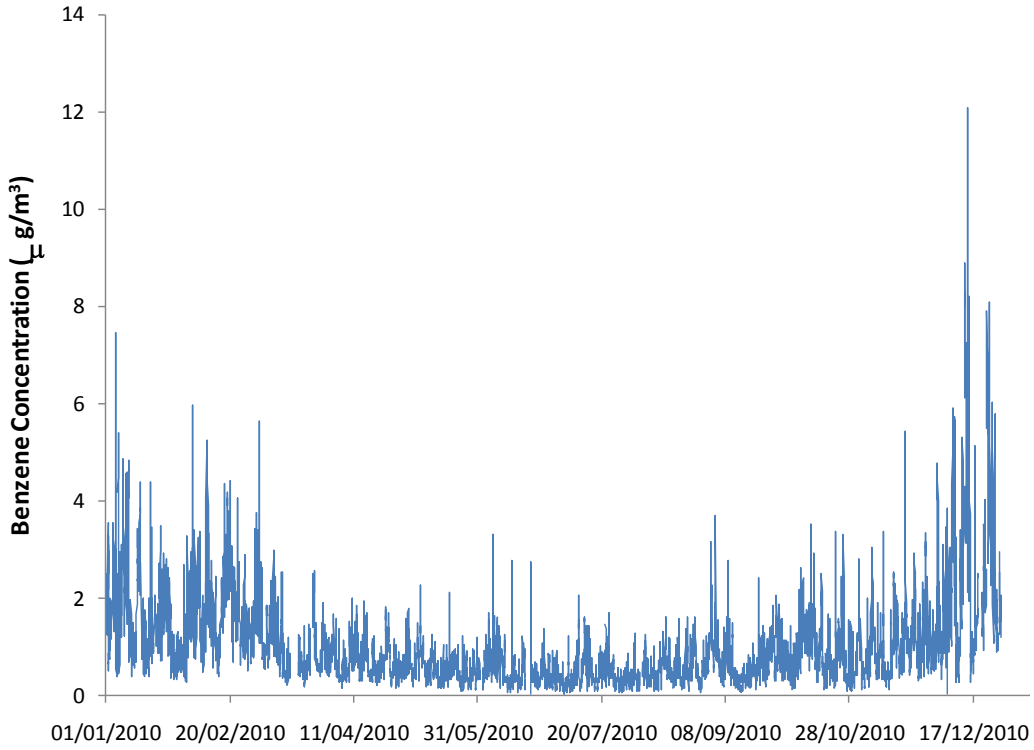


Figure 13 Glasgow Kerbside Automatic 1,3-Butadiene

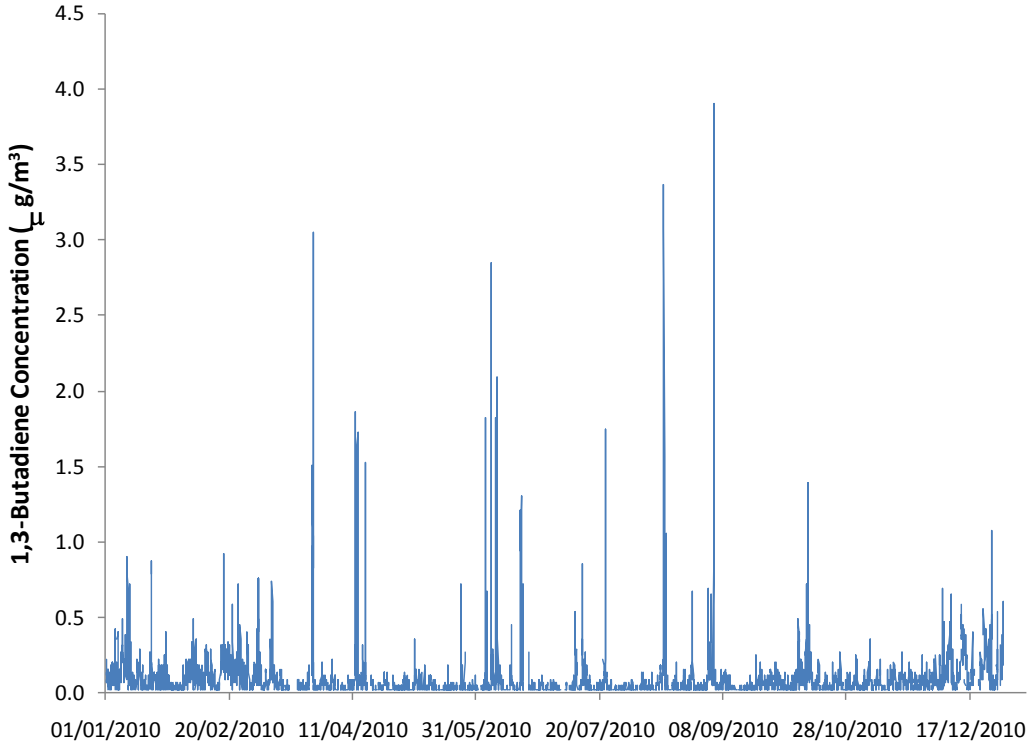


Figure 14 Harwell Automatic Benzene

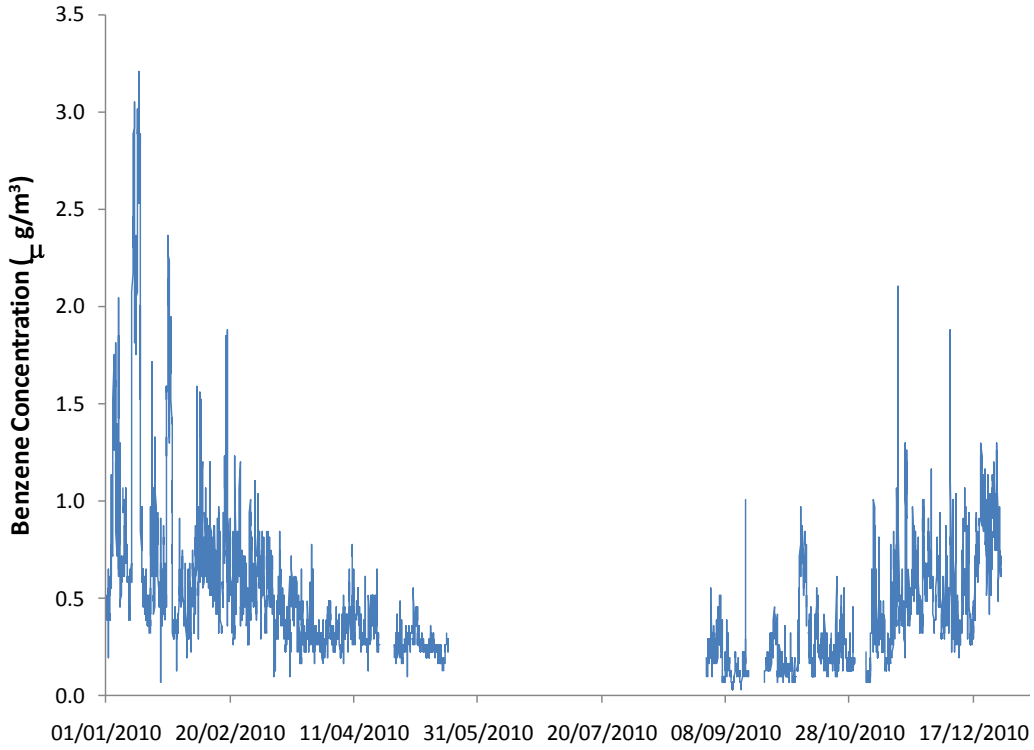


Figure 15 Harwell Automatic 1,3-Butadiene

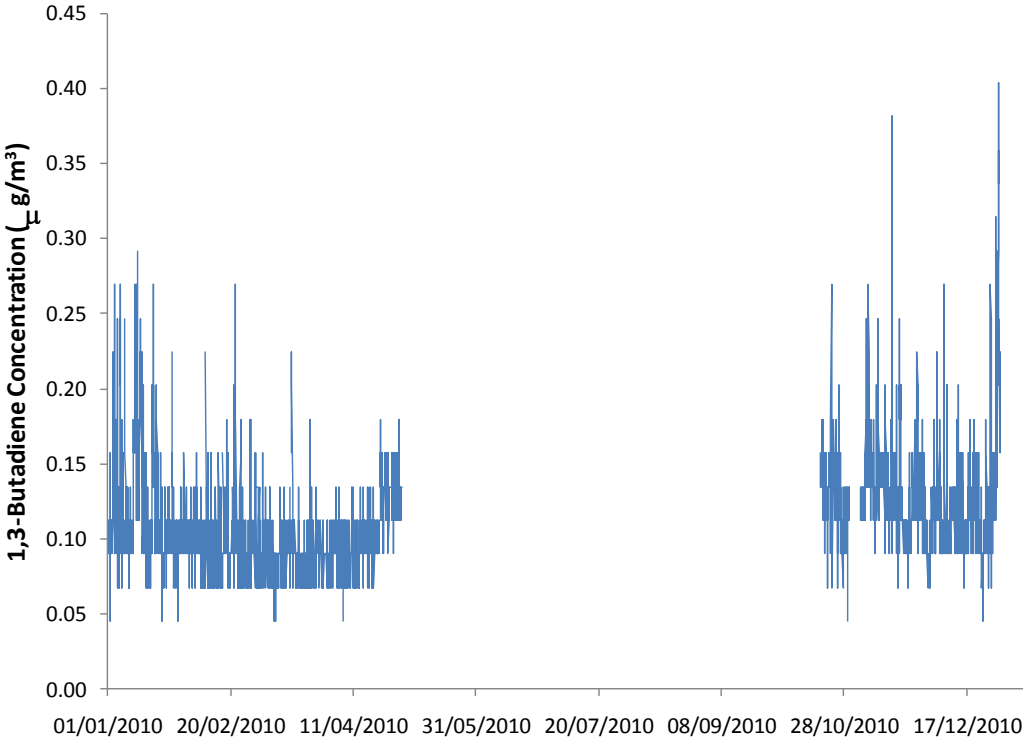


Figure 16 London Eltham Automatic Benzene

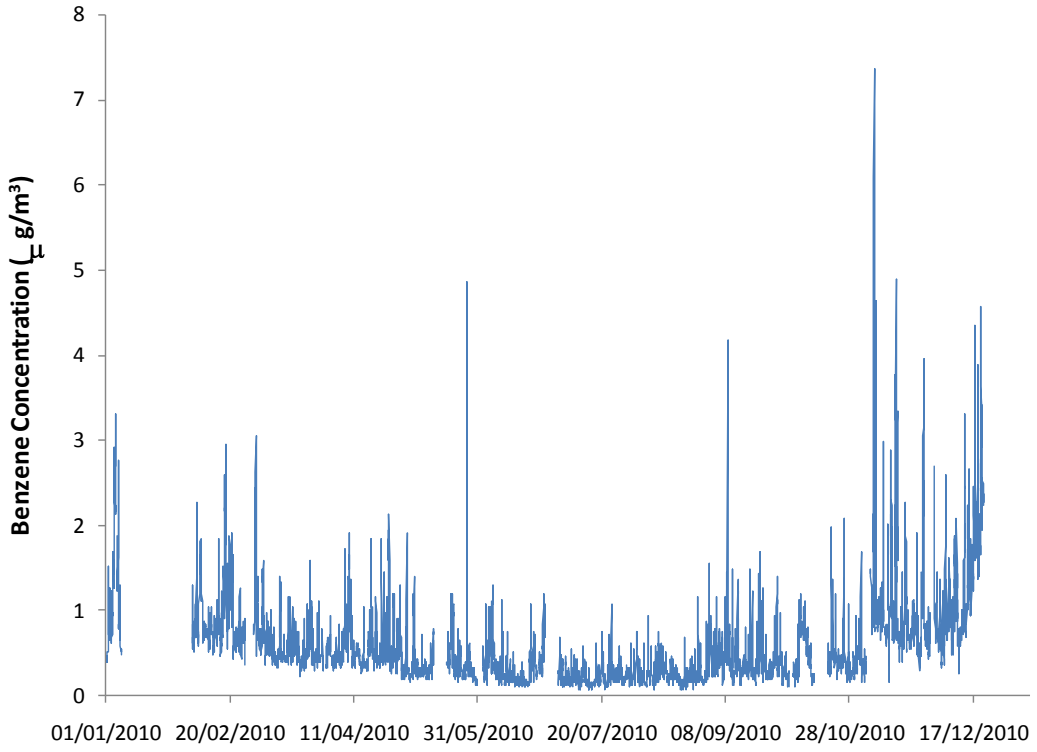


Figure 17 London Eltham Automatic 1,3-Butadiene

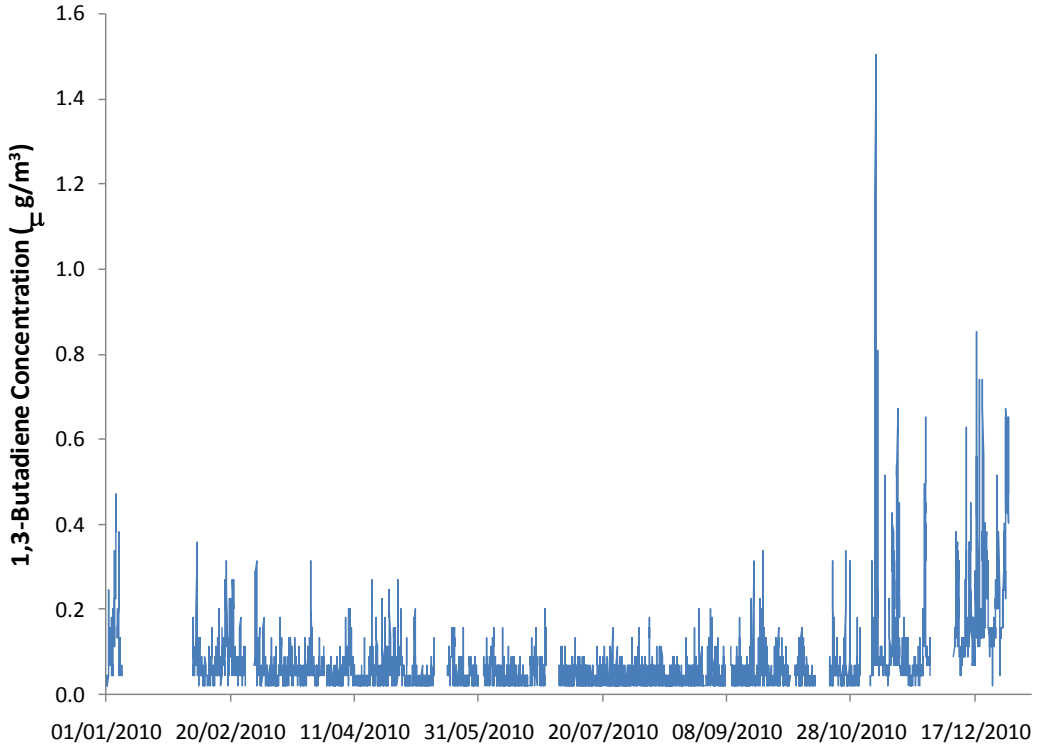


Figure 18 Marylebone Road Automatic Benzene

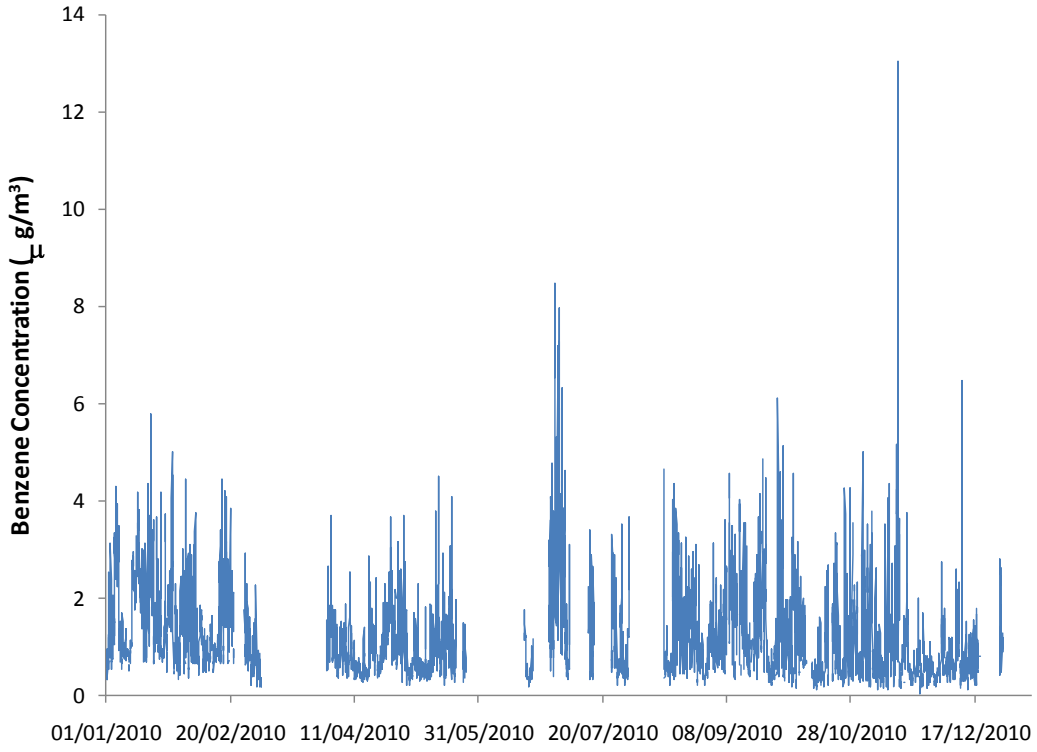
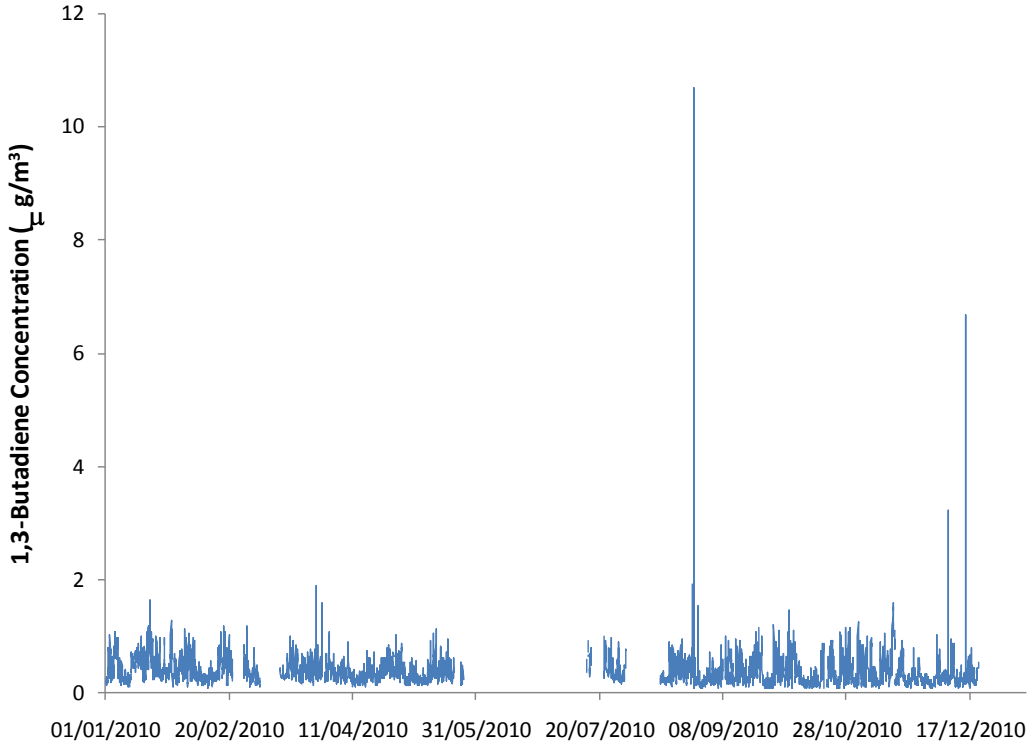


Figure 19 Marylebone Road Automatic 1,3-Butadiene



Non Automatic Fortnightly Mean Graphs for Benzene

Figure 20 **Barnsley Gawber Non Automatic Benzene**

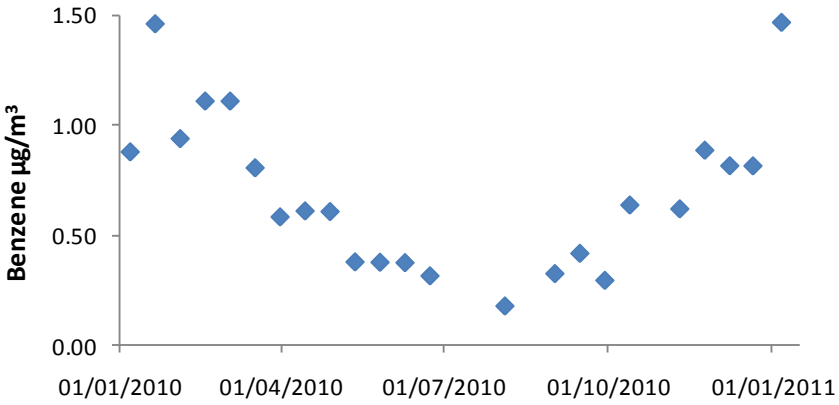


Figure 21 **Bath Roadside Non Automatic Benzene**

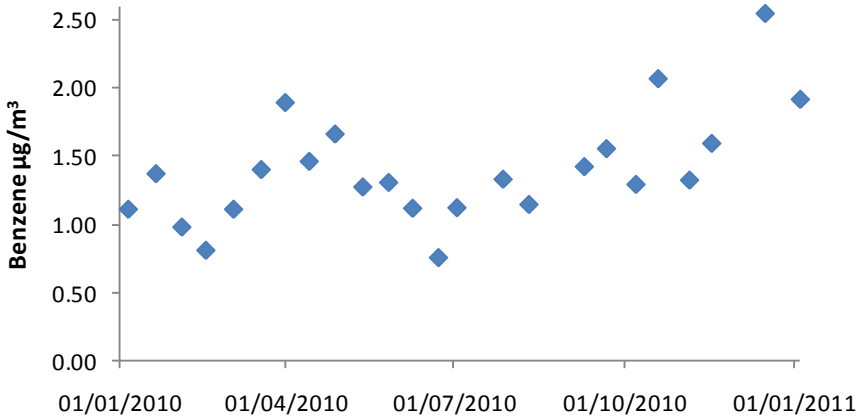


Figure 22 **Belfast Centre Non Automatic Benzene**

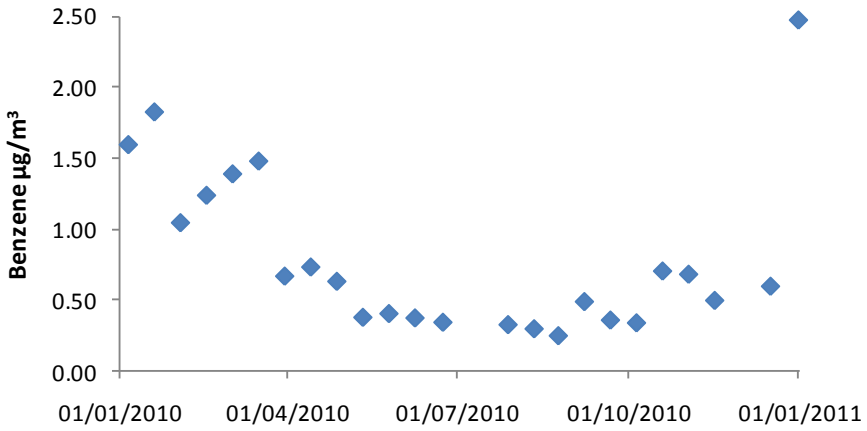


Figure 23 **Birmingham Tyburn Non Automatic Benzene**

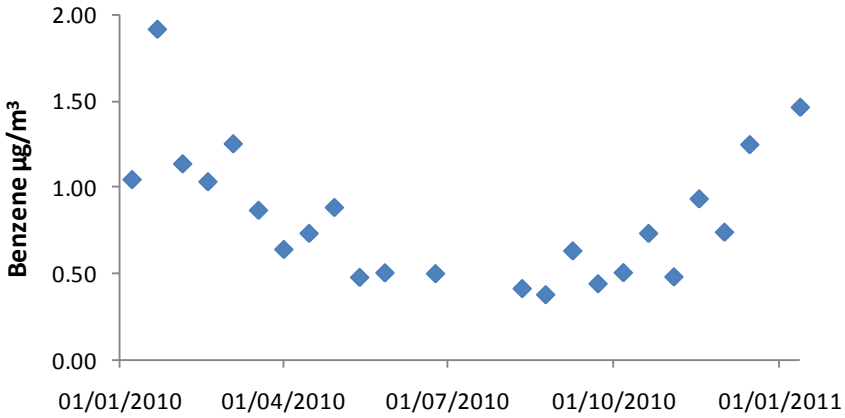


Figure 24 **Birmingham Tyburn Roadside Non Automatic Benzene**

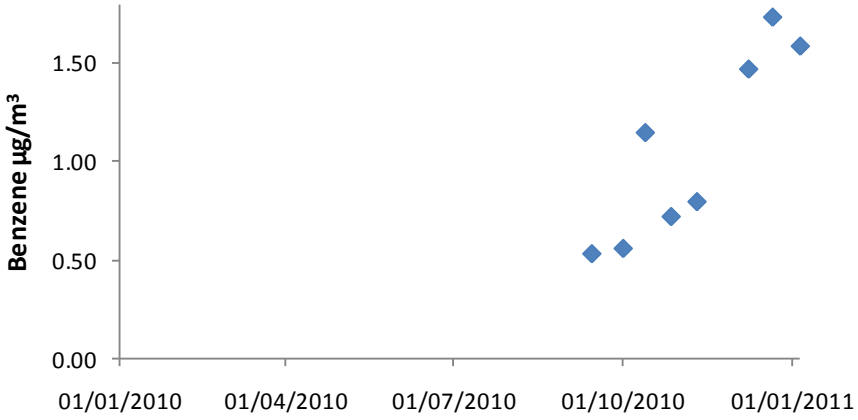


Figure 25 **Birmingham Roadside 2 Non Automatic Benzene**

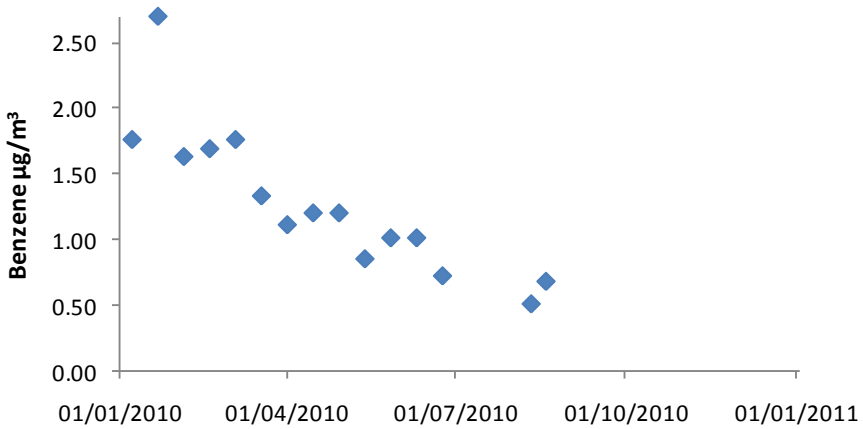


Figure 26 Bristol Old Market Non Automatic Benzene

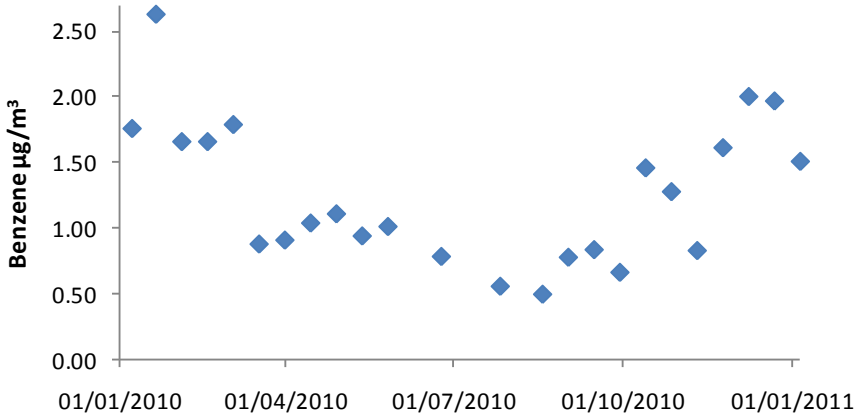


Figure 27 Bury Roadside Non Automatic Benzene

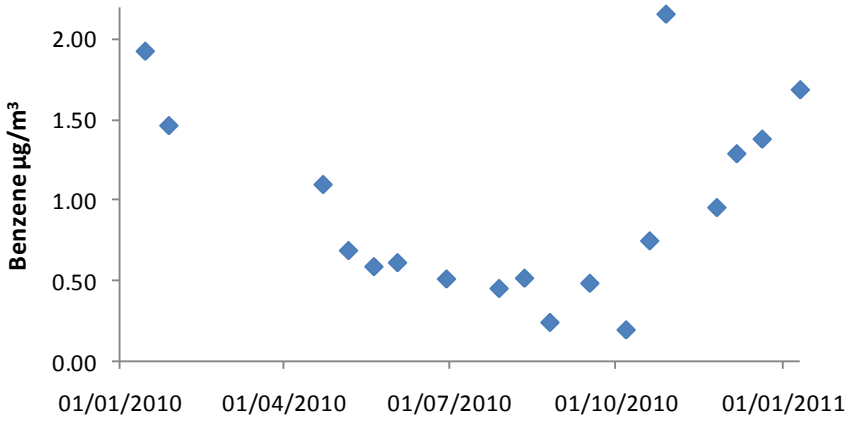


Figure 28 Camden Kerbside Non Automatic Benzene

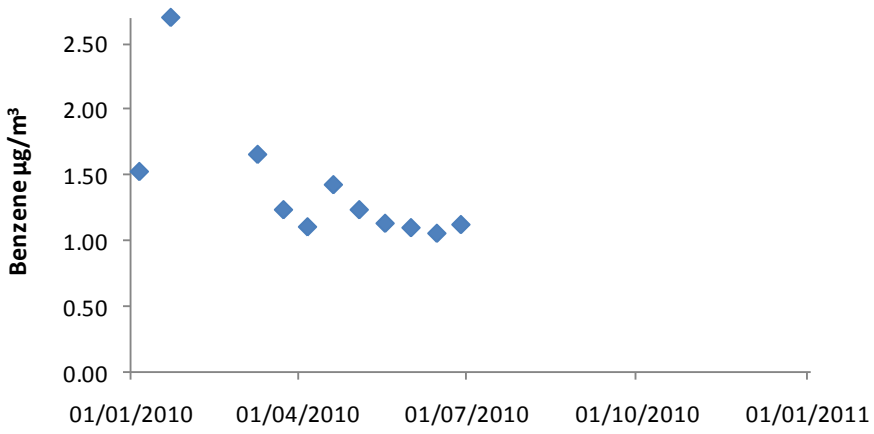


Figure 29 Cambridge Roadside Non Automatic Benzene

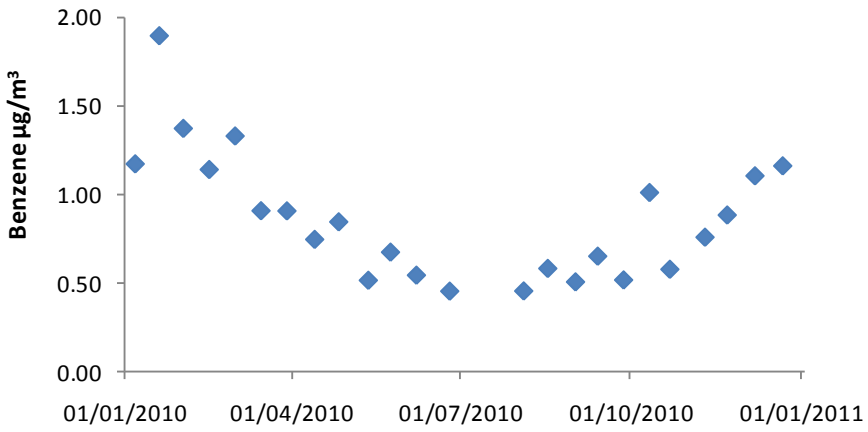


Figure 30 Carlisle Roadside Non Automatic Benzene

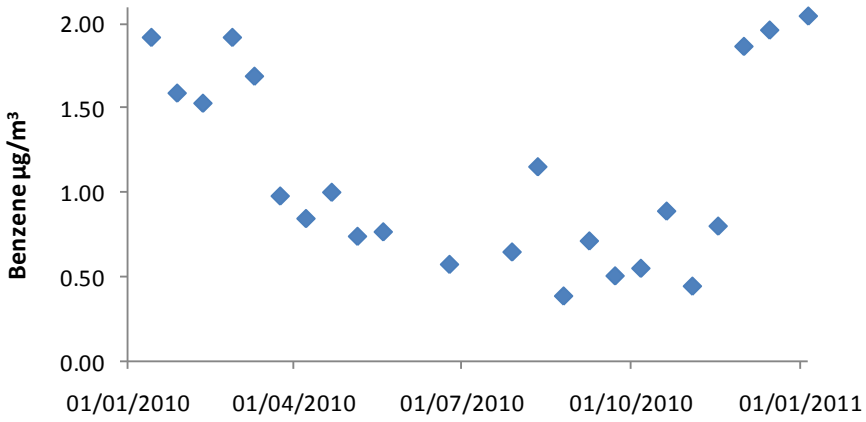


Figure 31 Chatham Roadside Non Automatic Benzene

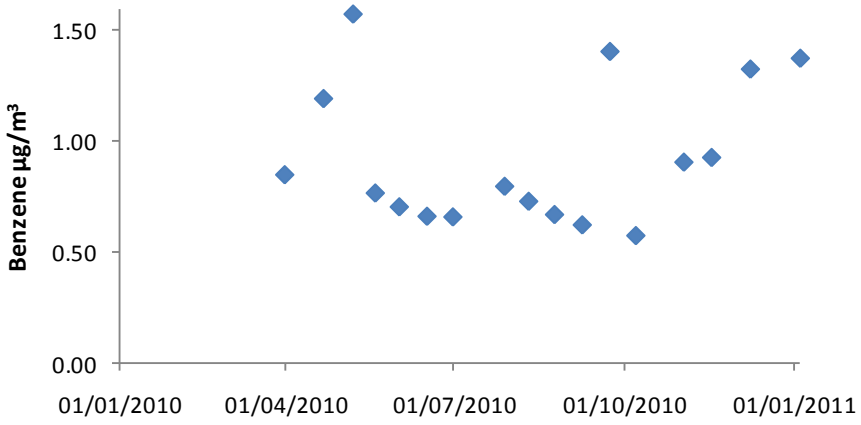


Figure 32 Chesterfield Roadside Non Automatic Benzene

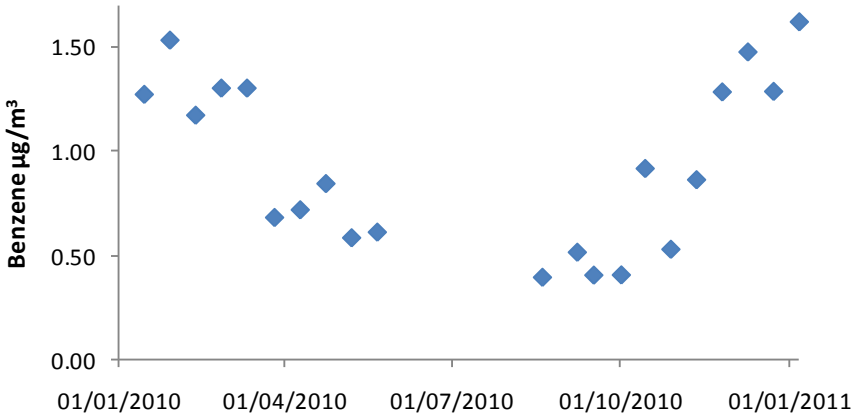


Figure 33 London Bloomsbury Non Automatic Benzene

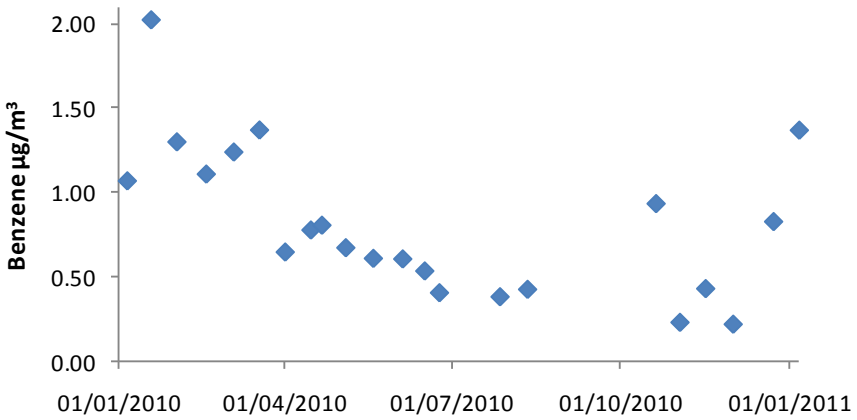


Figure 34 Coventry Memorial Park Non Automatic Benzene

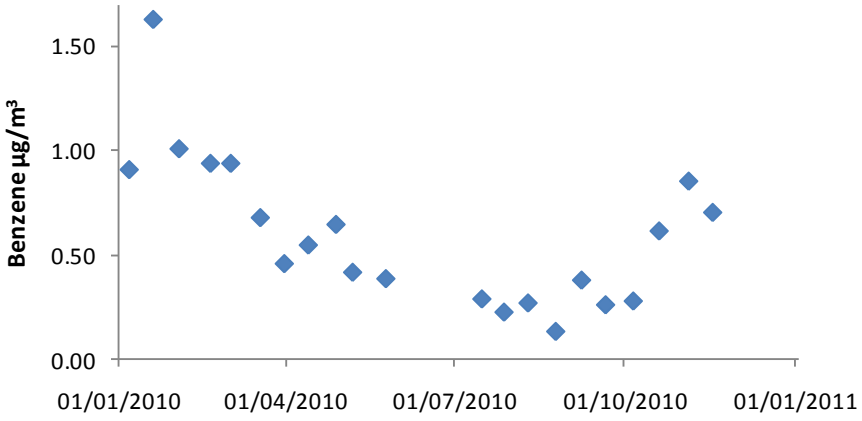


Figure 35 Stockton-on-Tees Eaglescliffe Non Automatic Benzene

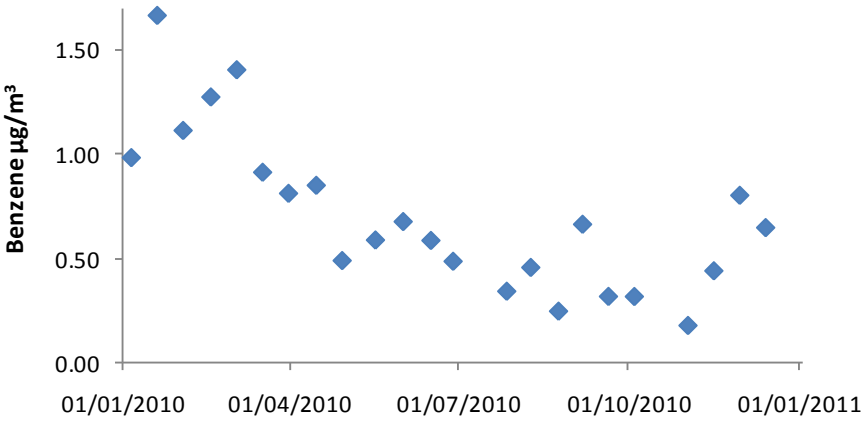


Figure 36 Haringey Roadside Non Automatic Benzene

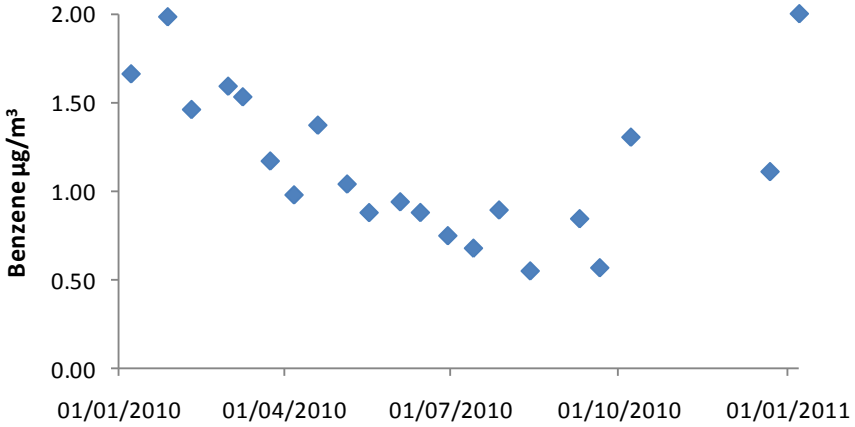


Figure 37 Killingholme Non Automatic Benzene

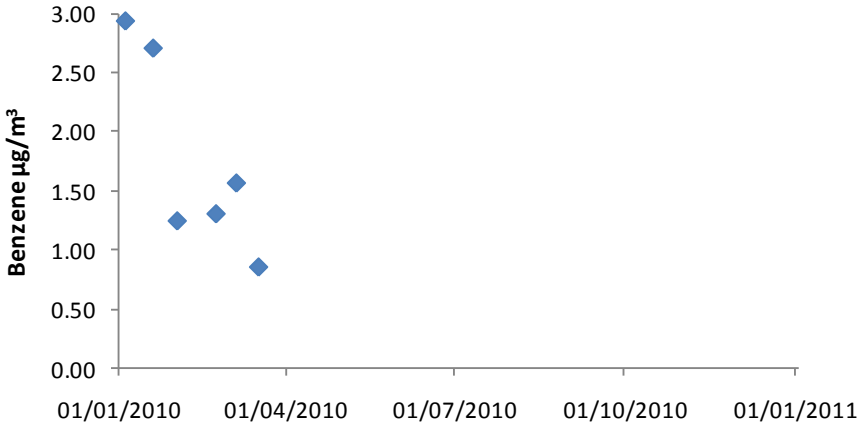


Figure 38 Glasgow Kerbside Non Automatic Benzene

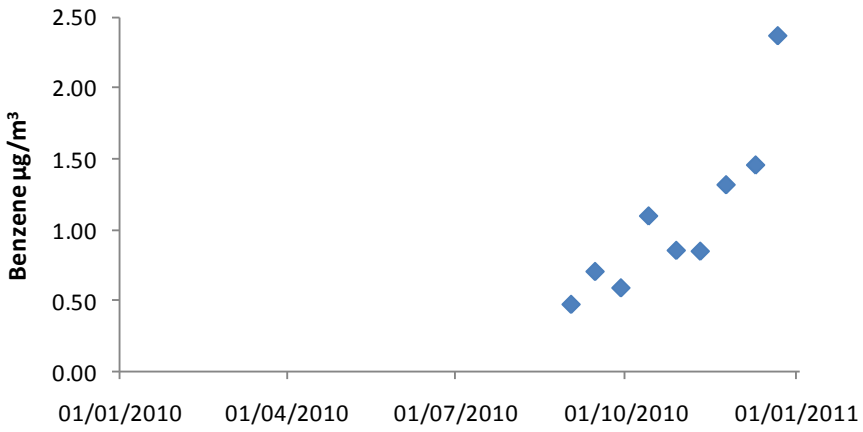


Figure 39 Leamington Spa Non Automatic Benzene

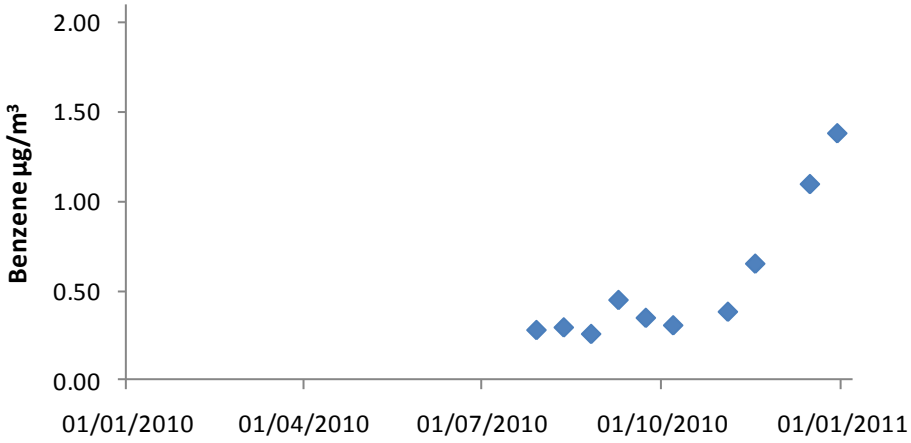


Figure 40 Leeds Centre Non Automatic Benzene

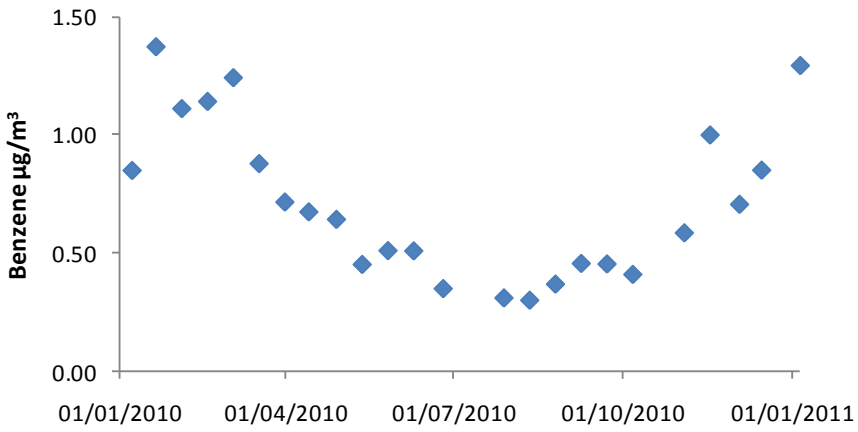


Figure 41 Leicester Centre Non Automatic Benzene

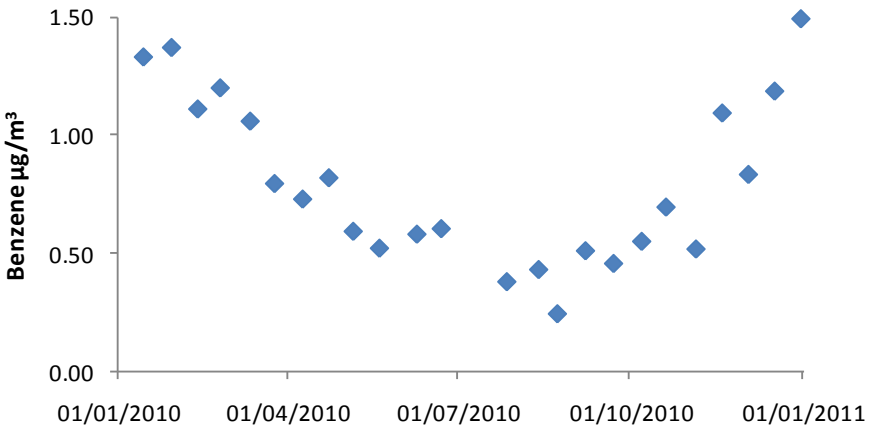


Figure 42 Liverpool Speke Non Automatic Benzene

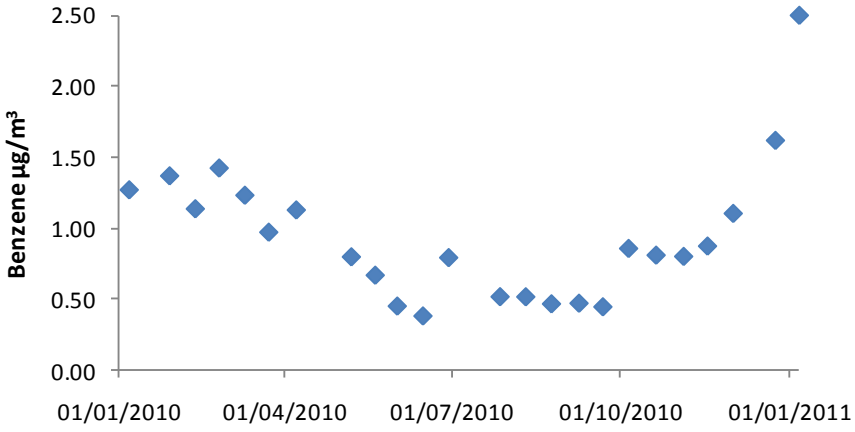


Figure 43 Manchester Piccadilly Non Automatic Benzene

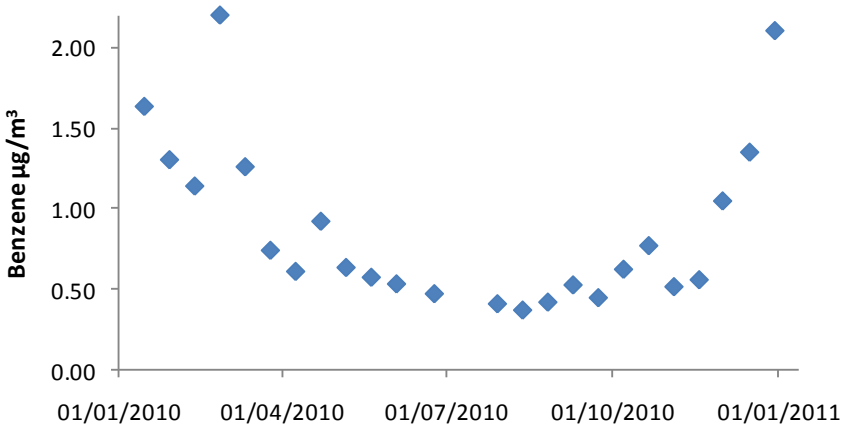


Figure 44 **Middlesbrough Centre Non Automatic Benzene**

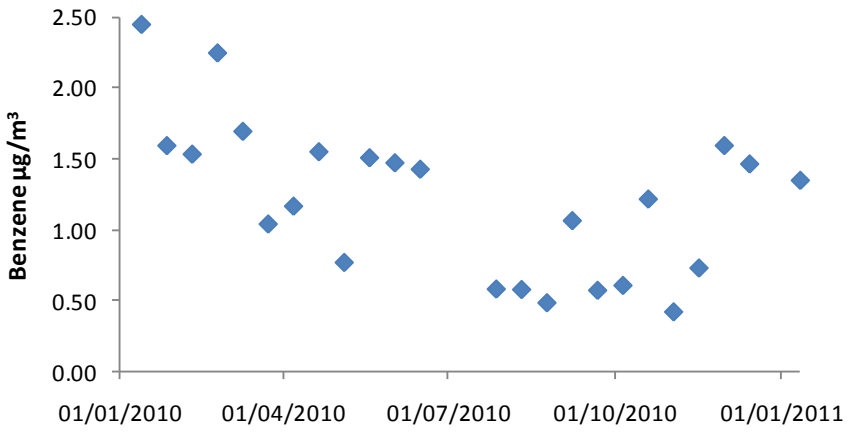


Figure 45 **Newcastle Centre Non Automatic Benzene**

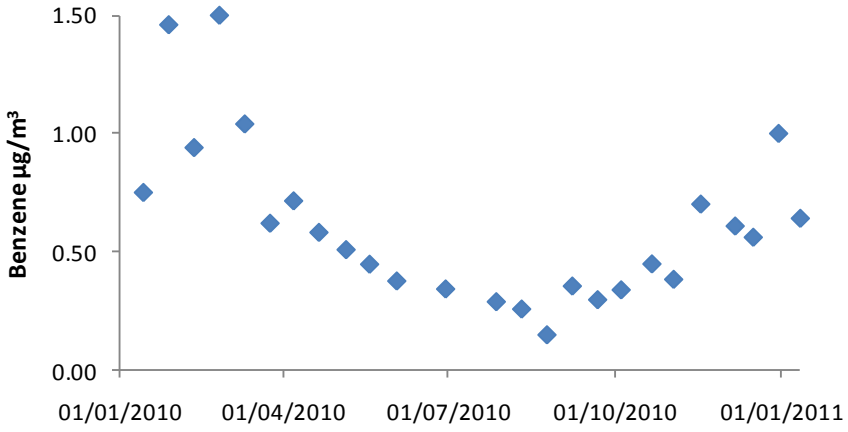


Figure 46 **Norwich Lakenfields Non Automatic Benzene**

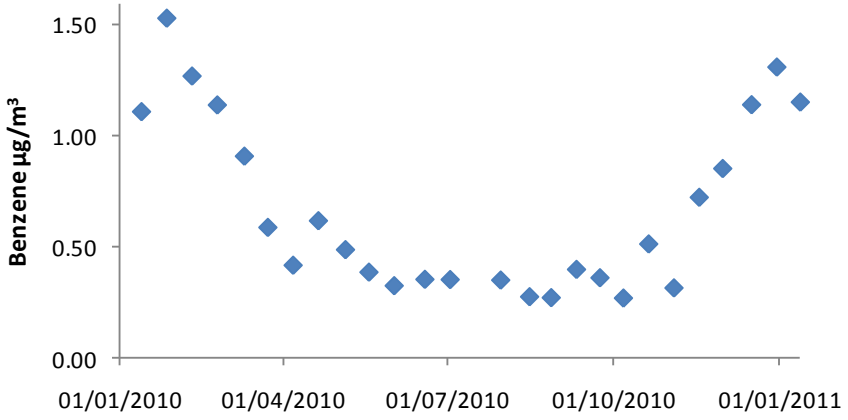


Figure 47 Nottingham Centre Non Automatic Benzene

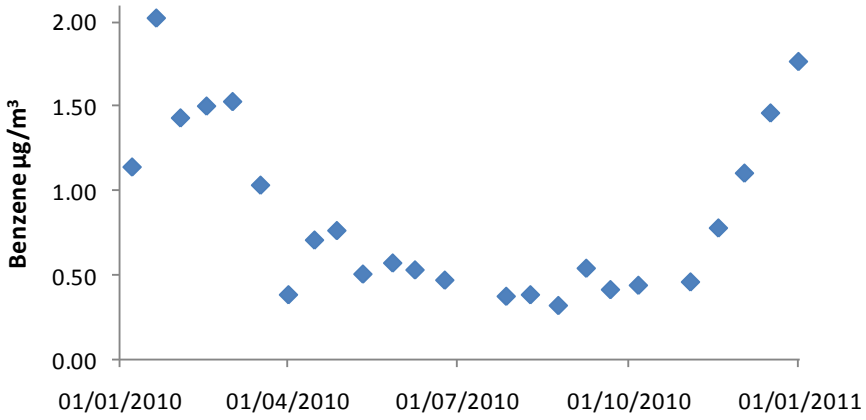


Figure 48 Northampton Non Automatic Benzene

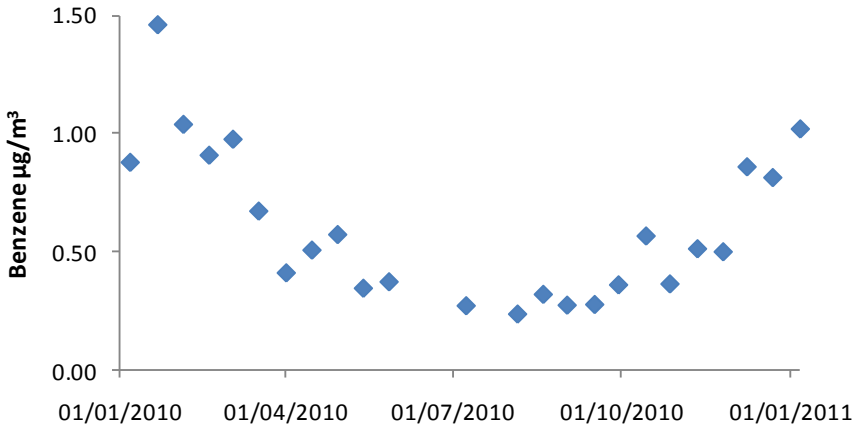


Figure 49 Oxford Centre Roadside Non Automatic Benzene

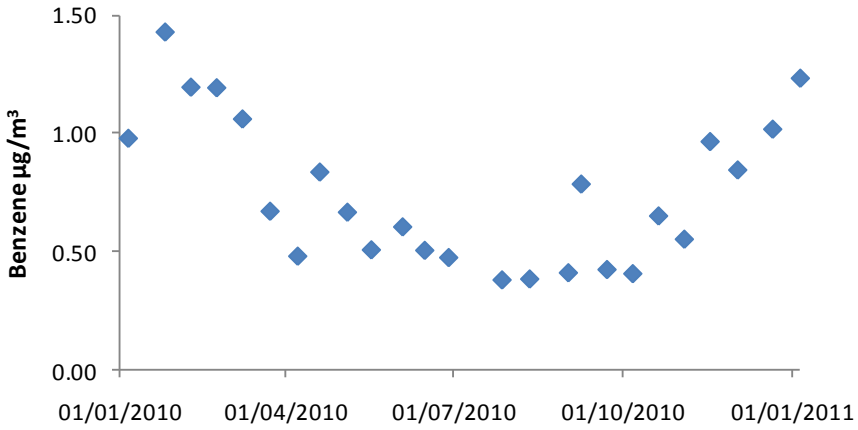


Figure 50 Oxford St Ebbes Non Automatic Benzene

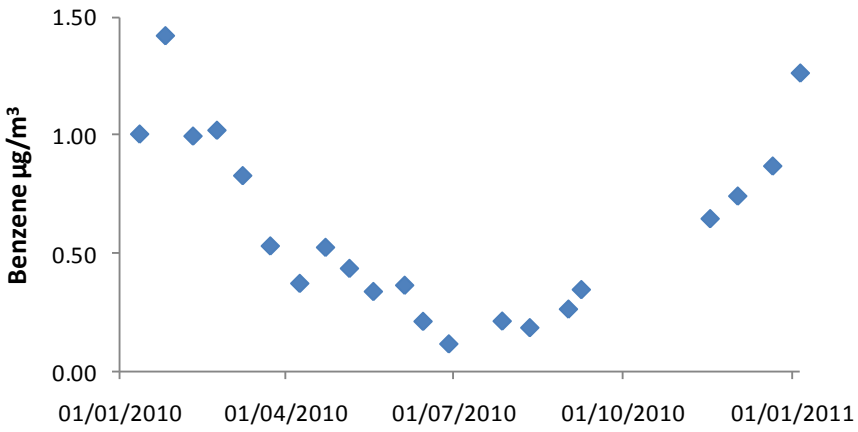


Figure 51 Plymouth Centre Non Automatic Benzene

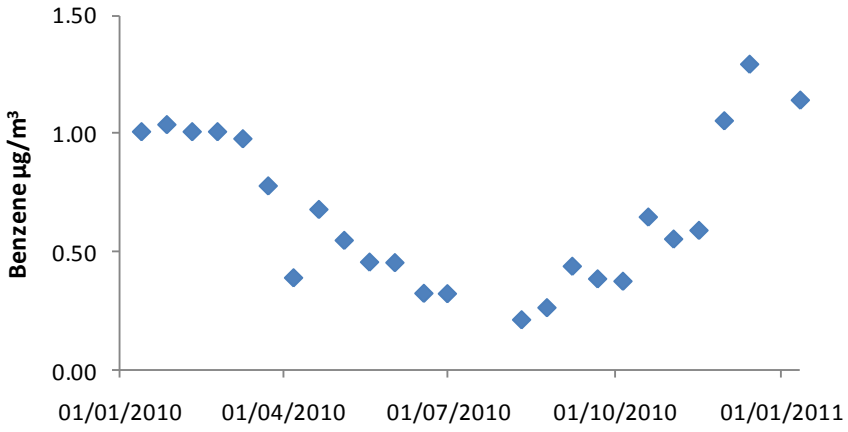


Figure 52 Sheffiald Centre Non Automatic Benzene

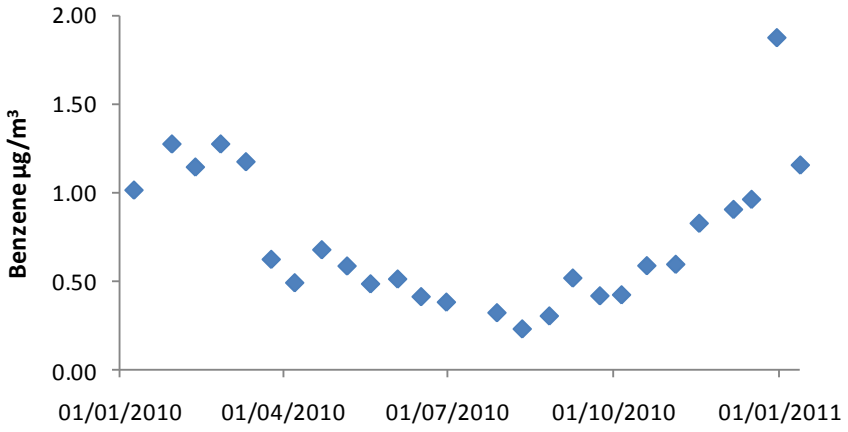


Figure 53 Southampton Centre Non Automatic Benzene

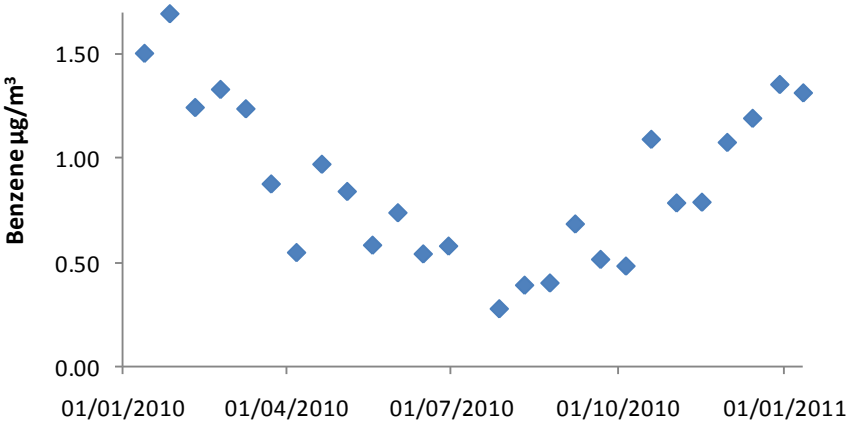


Figure 54 Stoke-on-Trent Centre Non Automatic Benzene

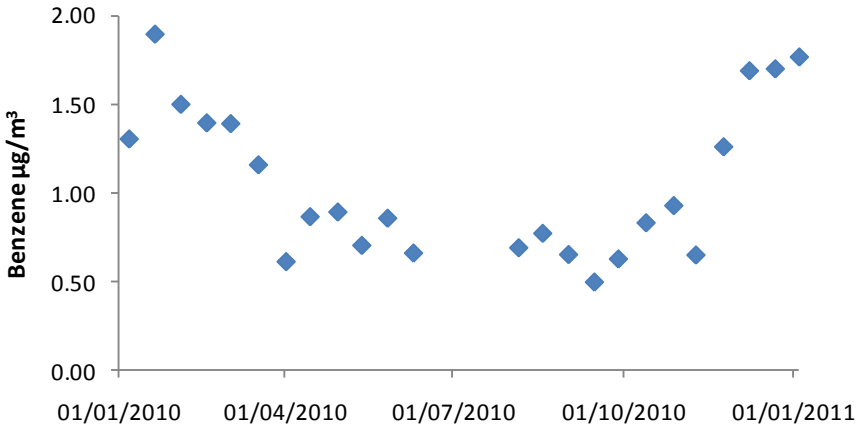


Figure 55 Wigan Centre Non Automatic Benzene

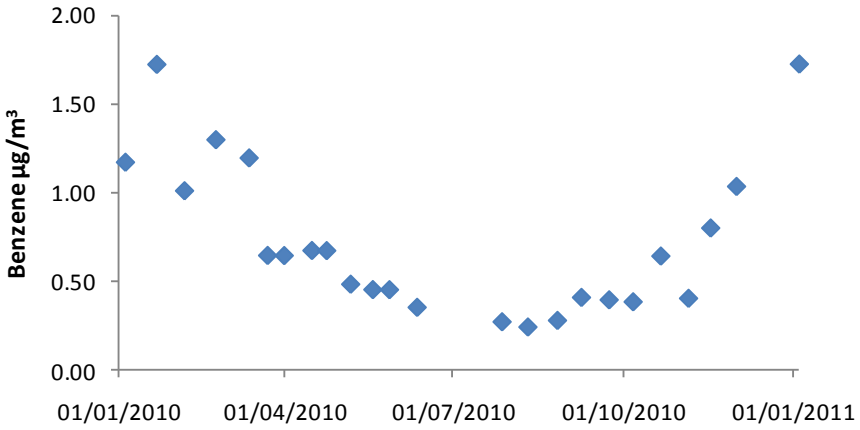
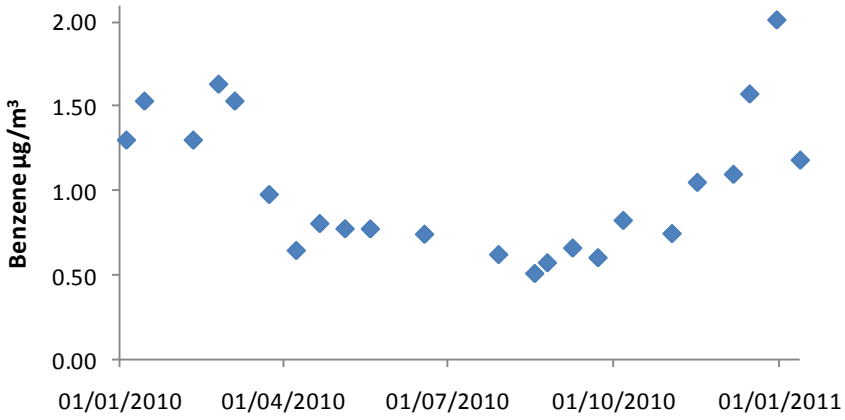


Figure 56 York Fishergate Non Automatic Benzene



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